PLANNING COMMISSION

GOVERNMENT OF PAKISTAN

ISLAMABAD

A STUDY OF THE CONTRIBUTION OF PRIVATE TUBEWELLS IN THE DEVELOPMENT OF WATER POTENTIAL IN PAKISTAN

WEST PAKISTAN

UNIVERSITY OF ENGINEERING AND TECHNOLOGY

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WEST PAKISTAN UNIVERSITY OF ENGINEERING AND TECHNOLOGY

LAHORE

Department of Civil Engineering

December 1970

Mr. Sarfraz Malik
Chief of Central Water and Power
Planning Commission
Government of Pakistan
Islamabad

Dear Sir:

Transmitted herewith is the Report on 'A Study of the Contribution of Private Tubewells in the Development of Water Potential in Pakistan.'

The contract was signed on May 15, 1969, and the work on the study started in early June, 1969. After the completion of the field work in February, 1970, the draft report was submitted in March, 1970. The present report has been prepared after incorporating the comments of the Project Advisors.

The Research Study gives, in addition to several economic, agricultural, and engineering characteristics of private tubewells, the number and their location, quantity of ground water pumped out of these, a comparative economic appraisal of private and public tubewells and the contribution that the private tubewells have made in the agricultural growth of the country.

The study has revealed very useful conclusions and recommends policies and action plans for the improved use of ground water in the fourth Five-Year Plan.

I wish to express my great appreciation of the assistance of those who have had a part in the work leading to the Report.

Very truly yours,

SAIYID NAZIR AHMAD
Ph.D; D.I.C.
Professor and Head
Department of Civil Engineering

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PREFACE

Pakistan is basically an agricultural country. We must not only be self sufficient in food production, but we must also improve our nutrition standard, increase farm income, and increase raw materials for industry and export. Water plays a most important role in the development of agriculture. Although we have been tapping our resources for water, and although the canals, rainfall and open wells play important roles, tubewells are another important source of water for irrigation purposes. This study, dealing with the contribution of tubewells in the development of water potential in Pakistan, is of national importance because the economical pattern of the use of tubewells is not sufficiently known.

It is laudible on the part of the Government of Pakistan Planning Commission to investigate this problem for inclusion in the planned development of water resources. The West Pakistan University of Engineering and Technology, Lahore, considers itself privileged to have undertaken the study on behalf of the Planning Commission.

The work was entrusted to a team of University personnel and was led by Dr. S. Nazir Ahmad, Head of Civil Engineering Department. The Faculty members on the Project team included Dr. M. Ikramullah, Mr. M. Aslam Rasheed, and Mr. Faiz Ahmad Chishti. They were assisted by young University graduates who were sent the length and breadth of the country to collect information on technical and agricultural aspects of the tubewells.

Without the help and co-operation extended in West Pakistan by the Water and Power Development Authority (WAPDA), Agriculture Development

Corporation (ADC), Agriculture Department, Agriculture University, and in East Pakistan by the Water and Power Development Authority (WAPDA), Agriculture Development Corporation (ADC), Industrial Development Corporation (IDC), and the Academy of Rural Development, the report would not have been comprehensive. The West Pakistan University of Engineering and Technology, Lahore, is very grateful to all these organizations.

The University team had access not only to the experts in this field available in Pakistan, but were guided by foreign experts as well. We appreciate the interest shown in this Project by both Dr. Maurice L. Albertson and Mrs. Della Laura Bennett of Colorado State University. We also appreciate their help during this study.

Mention should also be made of the co-operation of farmers and tubewell owners, but for which the studies would not have been completed.

We hope that the conclusions of this study will aid in the planning of a sound water resource program for the Fourth Five-Year Plan.

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SUMMARY

As Pakistan strives to become self sufficient in food, it is essential to utilize ground water for irrigation purposes. A large number of private and public tubewells have been installed during the past ten years, but their contribution in the development of water potential was not sufficiently known. The present study deals with the contribution of private tubewells in the development of water potential in Pakistan and the extent to which private sector development should be promoted to make effective utilization of private tubewells.

The number of private tubewells in Pakistan has been determined by actual counting. As regards information pertaining to engineering, agricultural and economic aspects, an extensive survey of about 4,000 representative tubewells all over Pakistan was carried out by trained graduate engineers and agricultural graduates and the data were recorded on carefully designed proforma. Pertinent information was also collected for public tubewells and non-tubewell farms for comparison with private tubewell farms.

At the end of 1969, there were 48,520 diesel operated private tubewells, 30,713 electric operated private tubewells and 8,519 public tubewells (of which 5,472 were in operation) in West Pakistan. There were 12 private tubewells and 1,286 public tubewells (of which 802 had been commissioned) in East Pakistan. The study also revealed that the rate of installation of private tubewells has declined during the last three years.

Major areas of concentration of tubewells in West Pakistan are the divisions of Sarghoda, Lahore, Multan, Bahawalpur and the district of

Gujrat, and those in East Pakistan are the districts of Dinajpur, Comilla and Mymensingh.

In the year 1969, over 14 MAF of water was pumped out by private tubewells and over 6 MAF by public tubewells in West Pakistan. Total pumpage from 802 private and public tubewells in East Pakistan was 0.217 MAF during the year 1969.

The private tubewells in West Pakistan show a capital investment in the private sector of over Rs. 689 million which includes Rs. 124 million loan from official agencies at the rate of 8 percent interest.

In areas of concentration of private tubewells, the cost of installtion of electric tubewell varies from Rs. 6,000 to Rs. 9,000, whereas that for a diesel tubewell is between Rs. 9,000 and Rs. 13,000. The respective operation costs are from Rs. 1,600 to Rs. 3,000 and Rs. 7,000 to Rs. 4,800.

The average cost per acre foot of water pumped works out to be Rs. 11 for private electric tubewells, Rs. 21 for private diesel tubewells, Rs. 17 for public tubewells without considering power facilities, and Rs. 20 while considering power facilities.

It is recommended that in order to have 25 percent increase in GNP from agriculture, about 30,000 private tubewells of average 1 cusec capacity should be installed in West Pakistan during the fourth Five Year Plan period. In East Pakistan, 10,000 tubewells of average 1.5 cusecs capacity and 26,000 low lift pumps of average 1.5 cusecs capacity should be installed in the districts of Dinajpur, Rangpur, Mymensingh, Pabna and Comilla under phased program.

STATEMENT

Colorado State University Contribution

The Colorado State University contribution was provided with the support of the Agency for International Development via contract No. AID/csd-2162, "Water Management Research in Arid and Sub-Humid Lands of the Less Developed Countries." The CSU contribution consisted of providing assistance during the data gathering period, review of the final report and printing of the final report.

LIST OF TERMS AND AGENCIES

ADBP	Agricultural Development Bank of Pakistan
ADC	Agriculture Development Corporation
CCA	Cultivable Commanded Area
Cusec	Cubic feet per second
GNP	Gross National Product
IDC	Industrial Development Corporation
Kharif	May - September growing season
KV	Kilovolt
KWH	Kilowatt Hour
LWDB	Land and Water Development Board
MAF	Million Acre Feet
PARD	Pakistan Academy of Rural Development
Rabi	October - April wheat growing season
SCARP	Salinity Control and Reclamation Projects
WAPDA	Water and Power Development Authority
WASID	Water and Soils Investigations Division of West Pakistan

CHAPTER I

INTRODUCTION

Pakistan is basically an agricultural country, so it requires adequate quantities of irrigation water. In East Pakistan, although annual average rainfall varies from 60 inches to 135 inches, there is not sufficient water throughout the year due to the problems of distribution. During the monsoons there is too much and during the five-month winter season there is too little rainfall.

Distribution of rainfall is also a problem in the Western wing. The distribution of water has been solved in part by a large system of dams and canals for transporting stored surface water for irrigation. However, the canal water is not sufficient for the irrigation requirements of the province, nor are all areas of West Pakistan served by the canals. This shortage, and nonavailability of irrigation water, requires developing additional water resources for the agricultural growth of the country. A general map showing both East and West Pakistan is presented in Figure 1.

Tubewells provide the means for utilizing ground water. In East Pakistan the installation of tubewells started only a few years ago. Thus, there are very few private tubewells in East Pakistan, and most of the tubewells that do exist have been installed by government agencies. However, during the last 10 years a large number of tubewells, mainly in the private sector, have been installed in West Pakistan for supplying irrigation water.

It is necessary to know the existing and potential contribution of private tubewells for agriculture in order to develop an irrigation

PLATE I

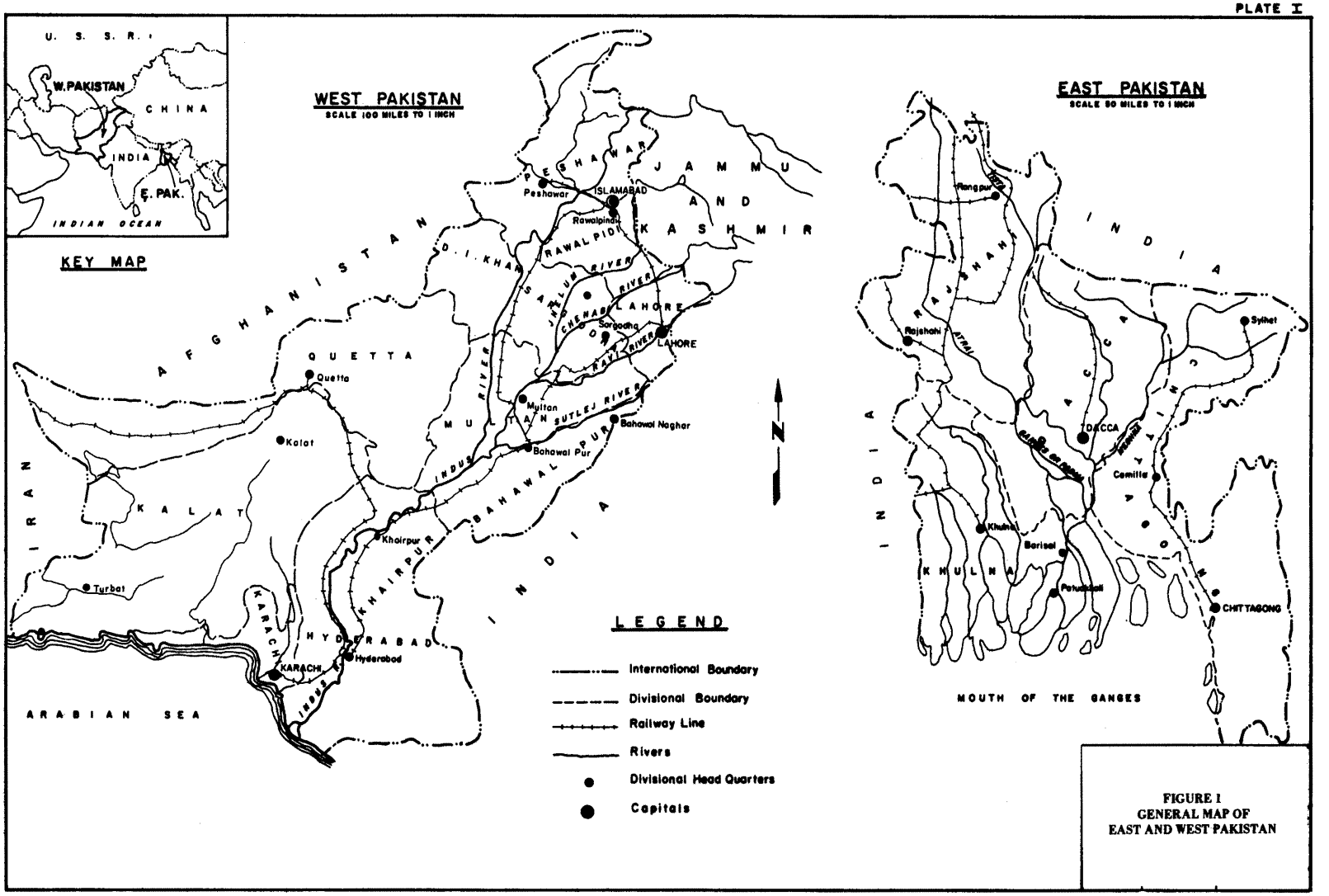

FIGURE 1
GENERAL MAP OF
EAST AND WEST PAKISTAN

policy. Although the installation of private tubewells in parts of Pakistan has been extensive, the pattern of this expansion had only been assumed from limited information provided by various agencies of the provincial governments. Information not available was the actual number of wells installed by the private sector, their locations, the quantity of water pumped, the cost of water pumped through private wells compared to the cost of ground water available through the public wells, the extent and amount of duplication of efforts in both public and private tubewells, and the extent private tubewells could be expanded and relied upon to augment the public tubewell program for providing water supplies for greater agricultural production in the fourth five-year plan.

This kind of information is vital if sound irrigation policy is to be initiated. Thus, the study described herein was instigated to cover the technical and economic aspects of these problems.

This study has two primary objectives: 1) to determine the contribution of private tubewells to the development of water potential in East and West Pakistan, and 2) to determine the extent the private sector should be assisted in order to develop the most effective utilization of private tubewells.

The Planning Commission, Government of Pakistan, approached West Pakistan University of Engineering and Technology, at Lahore, during early December 1968, to find out whether the University had the staff and facilities to undertake the project. After Dr. Maurice L. Albertson of Colorado State University discussed the details of the Project with the Vice-Chancellor of the University and the Head of the Civil Engineering Department, West Pakistan University of Engineering and Technology

communicated her willingness to undertake the project. Consequently, a contract was signed between the Planning Commission, Government of Pakistan, and the West Pakistan University on May 15, 1969.

Since then, four faculty members of the Civil Engineering Department have been permanently associated with the study. Experts from the Water and Power Development Authority (WAPDA), the Agricultural Development Corporation (ADC), the Irrigation Departments of East and West Pakistan, and the Institute of Development Economics, Karachi, were also consulted. The Faculty of the Agricultural Economics and Rural Sociology, West Pakistan Agricultural University, Lyallpur, was also formally associated with the project.

Services of engineering and agricultural graduates were employed for collecting data about tubewells. The field engineers visited all parts of the country to collect this information.

Student volunteers from the Engineering Institutions at Lahore, Peshawar, and Hyderabad were engaged for collecting information about the number of private tubewells in each Union Council in areas of concentration of private tubewells.

More than 250 persons have been connected with one or more aspects of this study.

CHAPTER 2

IRRIGATION IN PAKISTAN

Water resources development for agriculture is vitally important in both East and West Pakistan. In East Pakistan, water development has been primarily with regard to surface supplies, although some ground water has been utilized through public tubewells. In West Pakistan, surface water supplies are highly utilized through perennial and non-perennial canals and a series of barrages, dams, and canal headworks which control the diversion of river flows into the canals. There are also a large number of private and public tubewells tapping the ground water supply for irrigation water in West Pakistan.

2.1 Water Supply Sources in Pakistan

The total water supply available for irrigation in Pakistan is derived from three sources:

a. Rainfall

b. Surface water

c. Ground water

a. Rainfall

Rainfall is a most important source of water because agriculture in East Pakistan depends primarily on the monsoons. In West Pakistan, agriculture is less dependent on rainfall because of the extensive network of rivers, dams, and engineering structures.

Rainfall, although important, is not a reliable source of irrigation water because it is irregularly distributed over the year as well as within the same season. It is not always available at the time it is needed. Heavy rains generally occur in the summer months when the

temperatures are high and evaporation great. High intensities are not uncommon and result in heavy runoff. An important aspect of rainfall is that the rain stops before the maturity of Kharif crops and the sowing of Rabi crops, necessitating other forms of irrigation. The average annual contribution of rain to the crops in the canal-commanded areas in West Pakistan has been estimated by consultants of the World Bank at about 6 million acre-feet (MAF).[25]

b. Surface water

Pakistan is gifted with the presence of a number of perennial rivers. The Ganges Kobadak Project in East Pakistan consists of a system of gravity canals fed by a large pumping plant located on the Ganges River to serve about 330,000 acres of land. Phase I of the Kushtia unit is near completion. This will serve about 120,000 acres. Phase II of the Kushtia Unit and the Jessore Unit of this project will be completed later. Besides this, a plan for "Mechanical Cultivation and Power Pump Irrigation" has been started by the Agricultural Development Corporation (ADC). Under this plan, 19,000 diesel operated lowlift pumps of one to two cusecs capacity have been provided. These pumps are estimated to be commanding an area of about 750,000 acres.

In West Pakistan, the irrigation system consists of about 38,000 miles of canals which supplied 94.2 MAF of water during 1968-69. The entire cultivable commanded area (CCA) of the Indus Plain in West Pakistan is about 33 million acres, which requires a perennial water supply of about 202 MAF to develop an irrigation intensity of 150 percent. The average available annual flow of the rivers, however, is of the order of 135 MAF. Therefore, even with full development of the available

surface flow, there does not appear to be enough water to meet fully the irrigation requirements of all the presently designated CCA.

c. Ground water

Although tubewells may seem to be a direct and rapid way to meet the immediate irrigation requirements, not all of the available ground water may be suitable for irrigation. Water quality problems require detailed investigations before ground water resources can be fully developed.

Ground water is generally inferior to surface water, because it usually contains salts which may make it unsuitable for irrigation use. However, in most cases the quality of water is sufficient for irrigation, although it probably never reaches the quality of surface water.

Investigations carried out by such agencies as Water and Soils Investigations Division (WASID) of West Pakistan, WAPDA, Harza Engineering Company International, the World Bank Consultants, East Pakistan WAPDA, and EPADC show that vast areas in the Indus Plain in West Pakistan and some areas in East Pakistan have large quantities of good quality ground water.

2.2 Ground Water Recharge

Recharge to the ground water reservoir comes from infiltration from rainfall and seepage from rivers, lakes, reservoirs, canals, ditches, and irrigated fields. Recharge provides a perennial source of water supply part of which can be used.

No definite estimate of ground water recharge is available for East Pakistan. Detailed investigations are needed to determine the amount and location of usable ground water. However, large quantities of ground water are available in the districts of Dinajpur, Comilla, Mymensingh, Rangpur, Pabna, and Rajshahi.

In West Pakistan several studies have been conducted to determine the amount of usable ground water. Harza Engineering Company, general consultants to WPWAPDA, have estimated [22] potential recharge of ground water reservoirs in the canal irrigated areas of West Pakistan, as shown in Table 2.1.

TABLE 2.1

HARZA ESTIMATE OF GROUND WATER RECHARGE IN WEST PAKISTAN

Usable Ground Water	Northern Zone (MAF)	Southern Zone (MAF)	Total (MAF)
Rainfall and River Seepage	5.7	1.4	7.1
Link Canals Seepage	3.0	---	3.0
Canal Seepage	12.3	3.0	15.3
Water Course Seepage	3.6	0.9	4.5
Field Infiltration	9.8	2.2	12.0
Sub-Total	34.4	7.5	41.9
Unusable Ground Water	3.5	14.3	17.8
Total	37.9	21.8	59.7

Usable ground water recharge in West Pakistan under ideal conditions is estimated at 41.9 MAF, which can be pumped out annually for irrigation and other purposes.

2.3 Quality of Ground Water

The problem of water quality exists in both East and West Pakistan. The coastal areas have a problem of salt water intrusion. Detailed

investigations are needed in East Pakistan to determine the quality of existing ground water. However, it is known that the quality is good in the districts of Dinajpur, Rangpur, Mymensingh, Comilla, Pabna, and Rajshahi.

Consultants of the World Bank have estimated that in West Pakistan 14.2 million acres of the canal irrigated area lie over ground water of good quality, which can be used directly for irrigation. Another 4.5 million acres lie over ground water that has small amounts of harmful chemical elements, but can be used for irrigation after diluting with canal water.[25] The physical characteristics of the aquifer in the Indus Plain is generally favorable to ground water development, except in part of the lower Sind where the soil has a low permeability and the ground water is generally saline.

As shown in Table 2.2, the World Bank consultants have divided the cultivable commanded area of the Indus Plain into three zones:

a. Fresh water zone

Ground water containing not more than 1,000 parts per million (ppm) of total dissolved salts. This water may be used directly for raising crops in this zone.

b. Mixing zone

Ground water containing more than 1,000 ppm of salts but not more than 3,000 ppm in all areas, except the Lower Sind where the limit is 2,000 ppm. The lower limit in the Lower Sind is due to the increase of salinity with depth and higher salinity of the river water. In this zone tubewell water must be mixed with canal water in order to dilute it before it can be applied to crops.

c. Saline zone

In this zone ground water quality is more than 3,000 ppm in northern areas and more than 2,000 ppm in the Lower Sind. The tubewell water in this zone is highly saline and is not suitable for irrigation.

Outside the Indus Plain there are limited opportunities for ground water development, and, at present, very little information is available about them. However, it is clear that development of tubewells will need to be restricted to small groups of wells, also, potential yields will be small because of the arid climatic conditions in these areas. Figures 2 and 3 give the isograms of ground water salinity at 100 to 400 feet below the surface in the northern and southern regions of Indus Plain respectively.

TABLE 2.2

GROUND WATER QUALITY IN WEST PAKISTAN

(From World Bank)

(millions of acres)

Areas	Fresh	Zones Mixing	Saline
Peshawar and Swat Valley	0.58	0.10	----
Thal Doab and Indus Right Bank	2.03	0.99	0.60
Chaj Doabs	1.19	0.36	0.49
Rechna Doabs	3.37	0.84	0.49
Bari Doabs	3.95	1.34	0.54
Bahawalpur	1.29	0.47	1.75
Lower Indus	1.81	0.45	6.72
TOTAL	14.22	4.55	10.59

PLATE II(a)

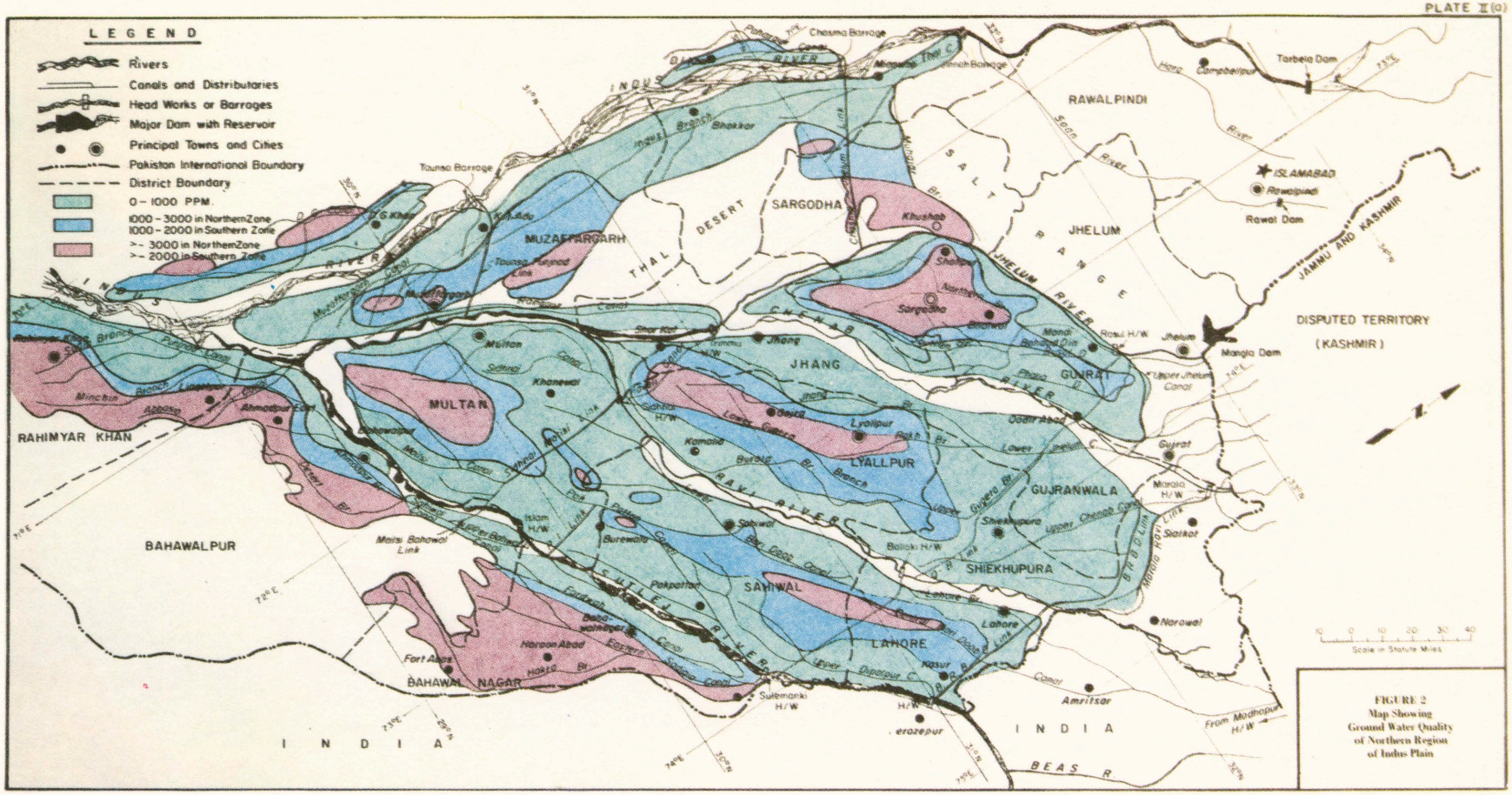

FIGURE 2
Map Showing
Ground Water Quality
of Northern Region
of Indus Plain

PLATE II(b)

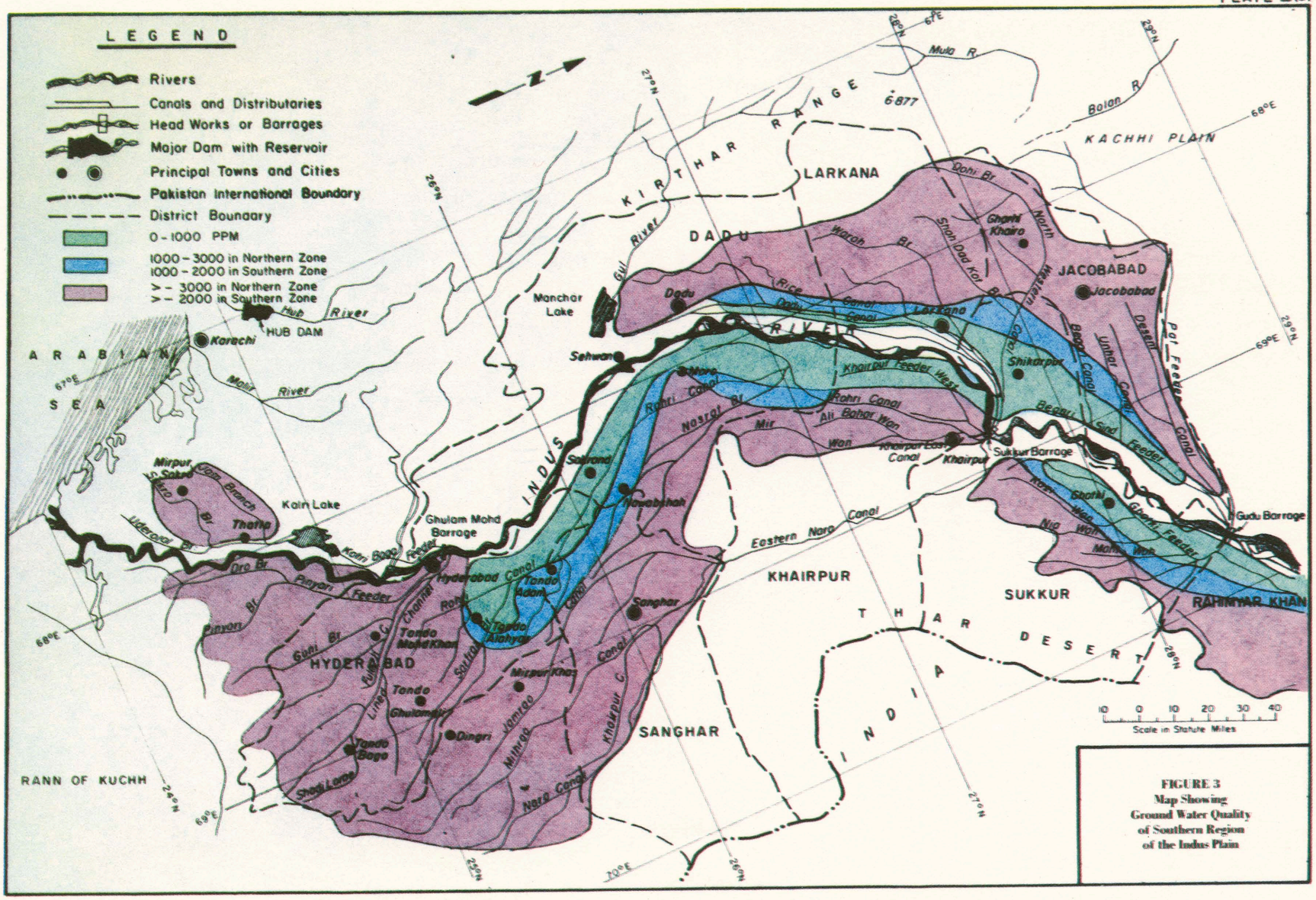

FIGURE 3
Map Showing
Ground Water Quality
of Southern Region
of the Indus Plain

2.4 Ground Water Depth

In East Pakistan ground water is generally available at depths of 10 to 20 feet below the surface. The water level fluctuates depending on the amount of rainfall and river stages.

Prior to the development of irrigation in West Pakistan the ground water was recharged from precipitation and seepage from the rivers; the effect of this precipitation and seepage on the water table was negligible. With the introduction of canal irrigation, however, the recharge increased, and the ground water levels started rising. This trend continued until evaporation began acting on the water table. This proximity of the water table to land surface has resulted in serious problems of drainage and soil salinity which reduced the agricultural productivity of extensive areas of the Indus Plain. Figures 4 and 5 show the extent of drainage problems in the northern and southern regions of the Indus Plain, respectively.

There has been a rapid increase during the past ten years in the utilization of ground water through tubewells. These tubewells have been installed mostly by farmers, but government agencies have also installed tubewells. Subsequent chapters of this report deal with the contribution of tubewells in the development of water potential in Pakistan.

PLATE III(a)

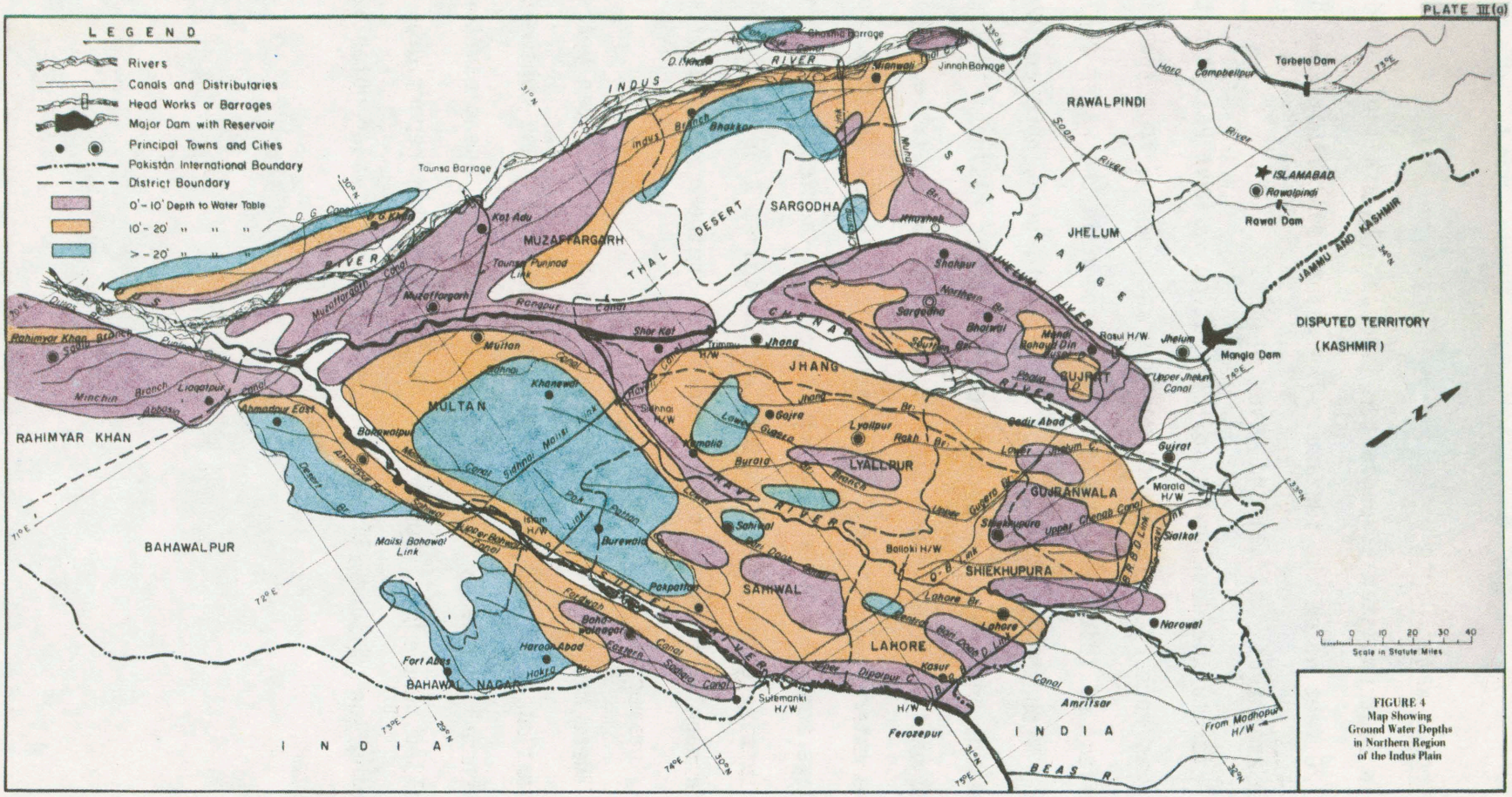

FIGURE 4
Map Showing
Ground Water Depths
in Northern Region
of the Indus Plain

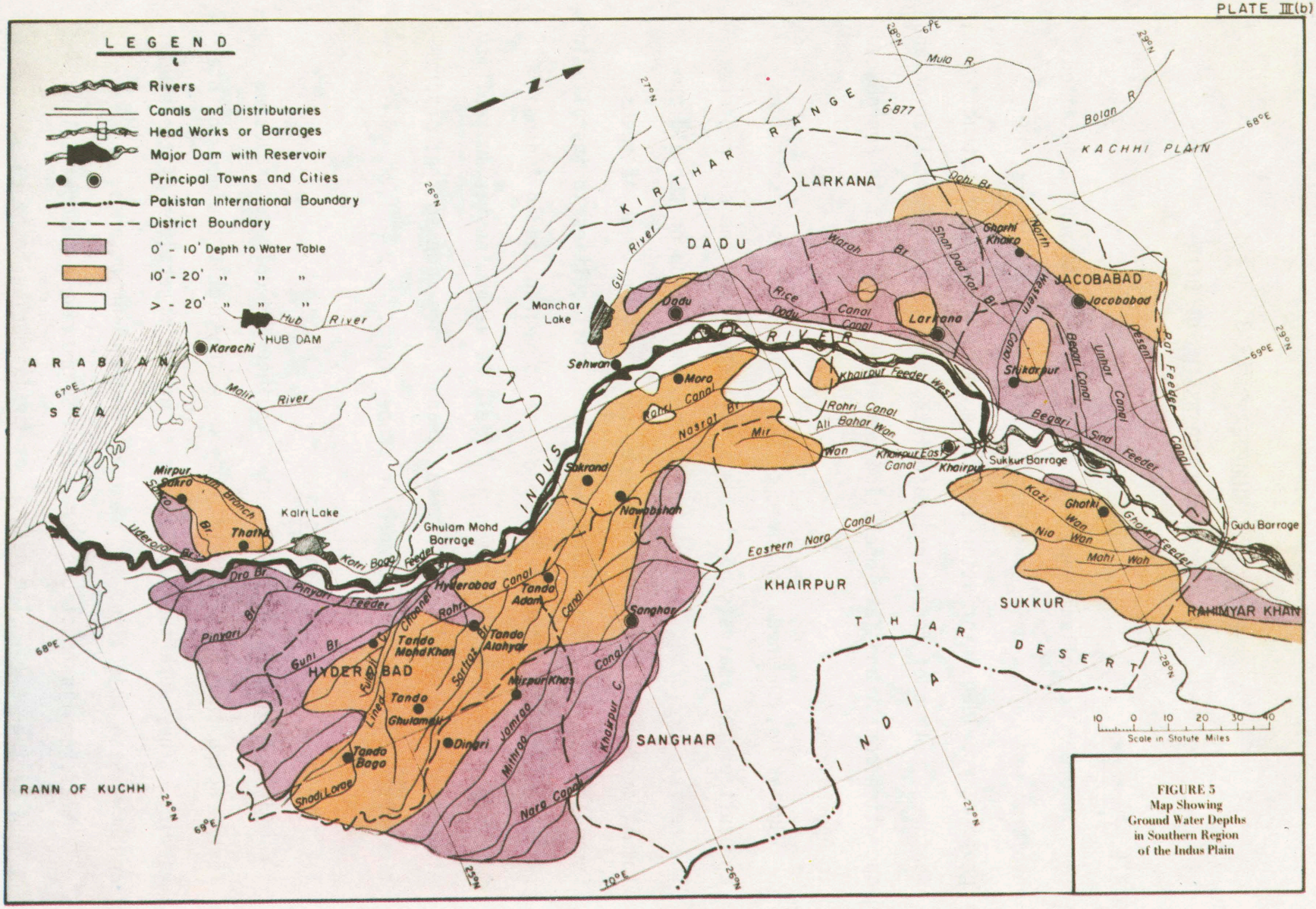

FIGURE 5
Map Showing
Ground Water Depths
in Southern Region
of the Indus Plain

CHAPTER 3

COLLECTION AND PROCESSING OF DATA

3.1 Proforma

In order to collect the necessary field information, a detailed proforma was designed in consultation with project advisors. The proforma provided information about the location, type, construction features, method of financing, materials, performance, installation and operation costs, and farm operation characteristics. It is reproduced in Appendix A.

Later on, the need to cover certain other factors was felt as a result of the analysis of the data collected from the old proforma. The revised proforma, in addition to the information on the old proforma, included information about cropping patterns, use of seeds, fertilizers, pesticides, canal water used, difficulties in installation of tubewells, etc. The revised proforma is reproduced in Appendix B.

The proforma was tested in the field to determine its suitability. After test interviews with farmers, changes were made so that information obtained could be recorded in proper form.

3.2 Training of Field Engineers

Field engineers were all recent engineering college graduates. Before sending them to the field, they were thoroughly trained in interviewing. They were thoroughly briefed on the objectives of the study and how these objectives are of great national importance.

Classroom instructions were given to provide a theoretical background of tubewells. The details of the tubewells to be noted on the proforma were also explained. The procedure for completing each item

of the proforma was discussed and practical demonstrations in the field were given. During the practical demonstrations in the presence of faculty members, the engineers were asked to interview farmers and record the information on the proforma in its appropriate place. The methods of measuring discharge, head, energy consumed, etc., were fully explained at the practical demonstrations and all difficulties encountered by individuals were corrected on the spot. When the field engineers were fully familiar with collecting the data and filling out the proforma, they were sent into the field.

3.3 Field Work

The following objectives were emphasized in collecting data:

a. Determination of the number of private tubewells

b. Survey of private tubewells

c. Survey of sample areas

a. Determination of the number of private tubewells

One of the objectives of the study was to determine the number and location of tubewells installed by private persons. The following methods were adopted.

1. Letters were sent to the Deputy Commissioners of all the districts in West Pakistan requesting up-to-date information concerning the number of private tubewells. Replies were received from about 60 percent of the districts.

2. Extra Assistant Directors of Agriculture in all the districts of West Pakistan were also requested to convey the number of tubewells in their districts. The response was slightly more than 50 percent.

3. Personal contacts were made with all the Revenue Offices of the Electricity Department of WAPDA. Their records were used to determine the number of private electric tubewells.

4. Chairmen of all the Union Councils (3,414 in number) in West Pakistan were sent reply-paid questionnaires requesting them to collect information on the number of private tubewells (diesel and electric tubewells separately) in their Union Councils and convey this data to the Project Office. The response was about 30 percent; a total of 1,037 replies were received. There was no follow-up.

5. Civil Engineering students of West Pakistan University of Engineering and Technology, Lahore; Engineering College, Jamshoro; and Engineering College, Peshawar, were employed to personally collect information in the areas of concentration of private tubewells. They were instructed to contact the Chairmen of Union Councils, Agricultural Field Assistants, Patawaries, etc., and to record the number of private tubewells in each Union Council. They were also required to conduct spot checks to verify the figures supplied to them.

The first three methods were initially employed, but the results thus obtained showed occasional discrepancies. In order to obtain more reliable estimates, the last two approaches were added. The last method, obtaining the number of tubewells by personally visiting each Union Council in areas of private tubewell concentration, was obviously most dependable. The results thus obtained were found to conform reasonably with those communicated by the Chairmen/Secretary of Union Councils, who returned our questionaires duly completed.

Also, questionnaires were sent to all the Deputy Commissioners of East Pakistan with the request to convey the number of the private

tubewells in the different districts. The replies obtained indicated that there are no private tubewells; all the tubewells have been installed by government organizations. The Pakistan Tea Association was also sent a similar questionnaire. The number of tubewells installed by public organizations was obtained by personally contacting the East Pakistan Irrigation Department, East Pakistan WAPDA, East Pakistan ADC, and East Pakistan Industrial Development Corporation (IDC).

To check the information obtained as detailed above, engineering and agricultural graduates were employed in East Pakistan to spot check various districts. Their results confirmed the earlier findings.

b. Survey of private tubewells

Private tubewells surveyed for collection of data for engineering, agricultural, and economic analysis were selected according to the following criteria for West Pakistan.

The field engineers were deputed to personally visit the revenue offices of the Electricity Department of WAPDA in West Pakistan and to collect the information regarding number of consumers with respect to electrically operated tubewells in each subdivision. The field engineers then visited the subdivisional offices located throughout West Pakistan and collected additional information as to the number of tubewells in each subdivision. A survey was then conducted for 4 to 8 percent of the electrically operated tubewells in each subdivision. About 2,000 electrically operated tubewells were surveyed in West Pakistan.

For data collection in areas of high concentration of private tubewells, i.e., the divisions of Sargodha, Lahore, Multan, and the district of Gujrat, a survey was carried out in each tehsil. The field engineer attempted to pick a representative sample based on the electrical-circles

information as to the size of holdings, nature of crops, depth of water table, distance from roads and railway lines, and the electrical grid. An attempt was made to get a scattering of locations. Random selection was not used. In areas of low tubewell concentration, the data collection was done in each district and within the district in representative areas according to the criteria already described. Electrically operated tubewells are near the electrical transmission lines and were generally easily accessible. Diesel tubewells are generally in the interior of the country and are not easily reached. Jeeps and other modes of transport available in these areas were used.

The survey of diesel tubewells was started after a preliminary estimate of the number of tubewells had been obtained from the Agricultural Census Organization of the Ministry of Agriculture. The field engineers were instructed to survey diesel tubewells according to the criteria already described. About 2,000 diesel tubewells were surveyed in West Pakistan. On the whole 4,046 private tubewells were surveyed. The district wise details are shown in Table 3.1.

The data collected was regularly sent by the field engineers to the Project Office where it was checked and catalogued.

Random proformas were selected and rechecked in the field by faculty members.

c. Survey of sample areas

In West Pakistan a special survey was conducted in certain selected areas to assess the contribution of private and public tubewells toward agricultural growth and to check some of the information already collected on agriculture by the staff. In this survey two teams of two persons each, one engineer and one agriculturalist, collected data from SCARP I,

TABLE 3.1

PRIVATE TUBEWELLS SURVEYED IN WEST PAKISTAN

Division	District	Tubewells Surveyed
Peshawar		79
	Hazara	3
	Mardan	27
	Peshawar	47
	Kohat	2
Malakand		9
D.I. Khan		51
	Bannu	2
	D.I.Khan	49
Rawalpindi		144
	Rawalpindi	--
	Campbellpur	2
	Jhelum	5
	Gujrat	137
Sarghoda		312
	Mianwali	30
	Sarghoda	88
	Jhang	93
	Lyallpur	101
Lahore		1,666
	Sialkot	381
	Gujranwala	672
	Sheikhupura	239
	Lahore	374
Multan		1,345
	Sahiwal	605
	Multan	535
	Muzaffargarh	153
	D.I.Khan	52
Bahawalpur		147
	Bahawalnagar	16
	Bahawalpur	99
	Rahimyar Khan	32

TABLE 3.1 PRIVATE TUBEWELLS SURVEYED IN WEST PAKISTAN - Continued

Division	District	Tubewells Surveyed
Khairpur		125
	Jacobabad	48
	Sukhur	26
	Lodhran	12
	Khairpur	30
	Nawabshah	9
Hyderabad		59
	Dadu	4
	Sanghar	6
	Hyderabad	45
	Tharparkar	2
	Thatta	2
Quetta		41
	Zhob	-
	Loralai	1
	Quetta	40
	Sibi	-
	Chagai	-
Kalat		17
	Kalat	17
	Kharan	-
	Makran	-
	Kachi	-
Karachi		51
	Karachi	51
	WEST PAKISTAN	4,046

SCARP II, and SCARP IV projects of WAPDA as well as from private tubewell farms in the Sargodha, Jhang, Shiwal, Multan, Khairpur, Gujrat, Rahim Yar Khan, and Bahawalpur districts. Some non-tubewell farms from the same areas were also surveyed for comparative studies.

In East Pakistan a special survey was conducted in the Dinajpur, Mymensingh, Comilla, and Dacca districts to determine the contribution made by public tubewells towards agricultural growth in the eastern wing. Data from non-tubewell farms and farms served by lift pumps were also collected for comparison with tubewell-irrigated farms.

3.4 Computer Programming

The revised proforma (Appendix B) was designed by Della Laura Bennett of CSU to permit adaptation to computer methods, including a unique feature of punching computer cards directly from the proforma. Services of WAPDA Computer Center were hired for punching cards, writing the source program, and executing the program, in consultation with University staff members.

In East Pakistan there are mainly public tubewells. Because of the small number of private tubewells, it was not considered worthwhile to assemble a computer program for the data. Necessary tabulation for the required analysis was performed in the Project Office.

A computer program was written to provide information for each division of West Pakistan except for the Peshawar and Malakand divisions which were combined.

CHAPTER 4

TUBEWELLS IN EAST PAKISTAN

4.1 Tubewells in East Pakistan

Installation of tubewells in East Pakistan has started only recently. This installation has been done mainly by government agencies such as East Pakistan Water and Power Development Authority (EPWAPDA), East Pakistan Agricultural Development Corporation (EPADC), East Pakistan Industrial Development Corporation (EPIDC), and government sponsored cooperative societies.

Both deep and shallow tubewells have been installed to tap ground water resources. Out of a total number of 1,298 tubewells in East Pakistan, 60 tubewells have been installed by the Public Health Engineering Department and are used to supply water for civic needs. For irrigation there are 1,232 tubewells of which 12 are private. A tubewell summary by district and government agency is given in Table 4.1. As seen from this table, the Dinajpur and Comilla districts represents a major concentration of tubewells.

a. EPWAPDA tubewells

The East Pakistan Water and Power Development Authority installed 380 electrically operated tubewells in the district of Dinajpur. Of these, 18 tubewells have been abandoned because of low discharge, leaving 362 tubewells in operation. Each tubewell commands an area of approximately 240 acres. At present EPWAPDA is supplying water to the farmers free of cost. This involves a 100 percent subsidy in installation as well as operational costs.

TABLE 4.1

PRIVATE AND PUBLIC TUBEWELLS IN EAST PAKISTAN

District	Number of Tubewells					
	ADC	WAPDA	PIDC	COOPS	Private	Total
Dacca	27	-	-	-	-	27
Faridpur	30	-	-	-	-	30
Comilla	187	-	-	97	-	284
Mymensingh	88	-	-	19	-	107
Jessore	49	-	-	-	-	49
Rajshahi	70	-	3	6	-	79
Bogra	27	-	3	-	-	30
Dinajpur	55	362**	12	6	-	435
Rangpur	89	-	8	-	-	97
Pabna	66	-	-	-	-	66
Kushtia	5	-	2	-	-	7
Noakhali	15	-	-	-	-	15
Sylhet	-	-	-	-	12	12
EAST PAKISTAN	708*	362	28	128	12	1,238***

* ADC had installed 708 tubewells by the end of 1969. Only 272 had been commissioned by that time.

** 380 tubewells were installed, 18 have been abandoned, and 362 are used for agriculture.

*** 60 tubewells of Public Health Engineering Department are in addition to this number.

Total cost of the EPWAPDA project is Rs. 134.6 million. Out of this, the cost of installation of 380 electrically operated tubewells is estimated at Rs. 45.6 million or Rs. 120,000 per tubewell. Thus, the capital cost averages Rs. 500/acre. The annual amortized capital cost is Rs. 55 per acre and the operation cost is estimated at Rs. 30 per acre. This gives a total annual cost of Rs. 85 per acre.

b. EPADC tubewells

The East Pakistan Agricultural Development Corporation (EPADC) has started a program for installing 2,000 tubewells in different areas of East Pakistan. About 1,000 tubewells are to be installed departmentally and through local contractors and 1,000 are to be installed under Yugoslavian credit by a Yugoslavian contractor.

At the end of 1969 ADC had installed 708 tubewells in the various districts of East Pakistan. Out of this total only 272 tubewells were in operation by that time, but the rest were installed in the field and ready to be commissioned. Most of the ADC tubewells are diesel operated and the average cost of the tubewells installed varies from Rs. 30,000 to Rs. 44,000 per tubewell. Each tubewell is estimated to irrigate about 100 acres.

The amortized annual capital cost is about Rs. 53 per acre and the annual operation cost is about Rs. 26 per acre which gives a total annual cost of Rs. 70 per acre.

The tubewell is leased to a group of farmers; lift pumps are also leased. The farmers bear only part of the cost in the first five years. The balance is met by the government out of the funds for the Rural Works Program. The rental charges and the subsidy is illustrated in Table 4.2.

The cost of the fuel is paid by the farmers from the first year. The operator for the tubewell is provided by ADC. The cost of operation is to be recovered in full from the farmers in the sixth year.

TABLE 4.2

RENTAL CHARGES OF EPADC TUBEWELLS*

Year	Total Charge (Rs)	Subsidy (Rs)	Charge to Farmers (Rs)
First	900	600	300
Second	1100	600	500
Third	1300	500	800
Fourth	1500	400	1100
Fifth	1800	300	1500

*Government of East Pakistan, Basic Democracies and Local Government Department Circular, No. 66 dated 18.1.1969.

c. Cooperative tubewells

Four cooperative societies one each in Comilla, Gaibanda in district Rangpur, Natore in district Rajshahi, and Gouripur in district Mymensingh, have also installed tubewells in East Pakistan.

The largest of these societies is located in Comilla and is working in collaboration with the Pakistan Academy of Rural Development (PARD), Comilla. In Comilla 97 tubewells have been installed under this project. The average discharge for each tubewell is 1.1 cusecs and the average installation cost is Rs.25,000. The average area supplied by each tubewell varies between 50 to 80 acres. The annual amortized capital cost is about Rs. 40 per acre while the operation cost is about Rs. 35 per acre, which gives a total annual cost of Rs. 75 per acre. Again, the annual expenditure is subsidized as is the case for ADC tubewells and lift pumps. The entire cost of the tubewell is recoverable in two to three years.

d. EPIDC tubewells

The East Pakistan Industrial Development Corporation (EPIDC) has also installed 28 tubewells in different districts of East Pakistan. These are mainly to supply water to factories and for irrigating sugarcane fields.

4.2 Ground Water Pumped Annually

On an average most of the EPADC tubewells are operated for about 150 days a year and 8 hours per day. This gives the average hours of operation as 1,200 hours per year. The Comilla tubewells are operated for 150 days a year and 16 to 20 hours per day. The 802 tubewells in East Pakistan that were in operation at the end of 1969 pumped 0.217 MAF of water during 1969 as is shown in Table 4.3. This low pumpage is because these tubewells operate only during the winter season.

4.3 Comparison of Different Irrigation Projects

The annual operating cost (including the amortized capital cost) of the WAPDA tubewells is the highest of all the government projects (Rs. 85 per acre). The low-lift pumps have the lowest annual operating cost of about Rs. 50 to 60 per acre. The annual cost of Comilla tubewells is less than that of the WAPDA tubewells but is still on the higher side. It has been reduced from Rs. 100 per acre to Rs. 75 per acre by making the farmers pay for the quantity of water used.

4.4 Benefits of Irrigated Agriculture

Controlled water supplies from gravity canals, tubewells, or lift pumps have benefited the agricultural production in East Pakistan in the following ways.

TABLE 4.3

ANNUAL PUMPING CAPACITY OF PUBLIC AND PRIVATE TUBEWELLS IN EAST PAKISTAN (1969) (Based on Survey Data)

District	No. of Tube-wells	Average Capacity Cfs	Combined Capacity Cfs	Averaged hrs. of Operation/ Year	Annual Pumping Acre-ft
Dacca	17	1.75	29.70	1,200	2,970
Faridpur	15	1.75	26.20	1,200	2,620
Comilla	220	1.50	330.00	2,250	61,600
Mymensingh	56	1.75	98.00	1,024	8,360
Jessore	10	1.75	17.50	1,200	1,750
Rajshahi	25	1.50	37.50	1,110	3,480
Bogra	3	1.00	3.00	480	120
Dinajpur	394	2.78	1,100.00	1,400	128,000
Rangpur	43	1.60	69.00	1,070	6,150
Pabna	5	1.75	8.80	1,200	880
Kushtia	2	1.00	2.00	480	80
Noakhali	-	-	-	-	-
Sylhet	12	1.00	12.00	1,200	1,200
EAST PAKISTAN	802	2.16	1,733.70	1,500	217,210

$$\text{Ann Pump/well} = \frac{2.16\ ft^3}{sec} \times 1500\ hr \times \frac{3600\ sec}{hr} = 2.16 \times 1.5 \times 3.6 \times 10^6 ft^3$$

$$= 11.7 \times 10^6\ ft^3 = \frac{11.7 \times 10^6}{4.4 \times 10^4}\ \text{acre-ft} = 2.66 \times 10^2\ \text{acre-ft/well}$$

$$\frac{2.66 \times 10^2\ \text{acre-ft}}{\text{well}} \times 8.02 \times 10^2\ \text{wells} = 21.3 \times 10^4\ \text{acre-ft}$$

$$= 213{,}000\ \text{acre-ft.}$$

(1) Fallow land and cultivable waste can be eliminated, especially in the winter season. If rain water is the only source of irrigation, almost the whole of the cultivated land remains idle in the winter season, for want of sufficient water. A good crop of rice, wheat, or vegetables is possible in this season which will improve income of the farmers.

(2) High flood waters often make it difficult to sow transplanted rice in the standing waters. Because the crop must be delayed, its maturity is also delayed. Irrigation water supplements the water needs at times when the monsoons are over.

(3) Availability of irrigation water stimulates use of improved inputs like fertilizers, improved seeds, plant protection, improved farm practices, etc.

(4) Controlled irrigation has made it possible to raise two to three crops from the same field in a year. In other words, average cropping intensity can be increased to about 250 percent against 137 percent practiced at present under rain-fed conditions.

(5) Yields are significantly better on the irrigated farms as compared to those on the nonirrigated farms.

The benefit of tubewell and lift irrigations in East Pakistan has been estimated from the data collected for this study. Table 4.4 shows that the net income on tubewell-irrigated farms is about Rs. 90 to Rs.266 per acre more than that on non-tubewell farms.

TABLE 4.4

NET INCOME ON TUBEWELL AND NON-TUBEWELL FARMS IN EAST PAKISTAN

(Based on Survey Data)

District	Gross Income (Rs/Acres)		Gross Expenditure (Rs/Acres)		Net Income (Rs/Acres)		Additional Net Income on Tubewell Farm (Rs/Acres)
	Tube-well Farm	Non Tube-well Farm	Tube-well Farm	Non Tube-well Farm	Tube-well Farm	Non Tube-well Farm	
Dinajpur	628.73	449.82	225.66	160.00	403.07	289.82	113.25
Comilla	867.34	395.30	369.27	163.55	498.07	231.75	266.32
Mymensingh	521.60	317.40	235.90	152.60	285.70	164.80	120.90
Dacca*	-	540.56	-	228.63	-	311.93	-

*Irrigated from lift irrigation system in Demra Project of EPADC, i.e., water is "free" or completely subsidized - cost of low-lift pumps needs to be included for comparison.

Table 4.4 indicates that in Dinajpur additional income on tubewell farms served by WAPDA tubewells is Rs. 113 per acre. Subtracting the annual cost of water at Rs. 85 per acre the net additional income comes to Rs. 28 per acre. Each tubewell serves an area of 240 acres, therefore, the net additional annual income per tubewell is estimated as Rs. 6,720. The amortized capital cost is such that the capital cost of the tubewell is recoverable over a 20 year period.

The Comilla tubewells give an additional income of Rs. 266 per acre. Subtracting the annual cost of water at Rs. 75 per acre the net additional income comes to Rs. 191 per acre which is enough to recover the cost of the tubewell in two to three years time.

The Mymensingh tubewells of ADC provide an additional income of Rs. 121 per acre and the net additional income (less annual cost of water) from the tubewells comes to Rs. 42 per acre. The cost of the tubewell is recoverable in about seven years.

4.5 Returns to the Government

Despite the benefits obtained by the farmers from irrigation projects in East Pakistan, returns to the government have been meager. All the irrigation projects including the installation of tubewells are government operated. Only the cost of fuel from each tubewell is paid in full by the farmer, maintenance is subsidized to the extent of 40 to 70 percent. The capital cost incurred by the Government is not recovered, and the farming community has not participated so far in financing the program of installing tubewells. This is in contrast to what has happened in West Pakistan, where almost 90 percent of the capital investment and 100 percent of the maintenance and operation costs of private tubewells are assumed by the farmers themselves.

In East Pakistan the program of tubewell installation without participation of the farmers is apt to heavily tax government resources. The farming community, with credit and technical help from the government, must undertake private development of tubewells and lift irrigation. As already discussed the returns from Comilla tubewells are large enough to recover the entire cost of tubewells in about three years. The cost of ADC tubewells is recoverable in about seven years.

4.6 Number of Tubewells Required for the Fourth Five-Year Plan

Agricultural production can be increased the most from improvements in fertilizers, seeds, plant protection, and application of irrigation

water. For an estimated increase in agricultural production in East Pakistan of 5 percent per annum during the fourth plan it is estimated that the use of these agricultural resources, including the construction of field canals, would increase the Gross National Product (GNP) from agriculture 15 percent during the plan period. Lift pumps, tubewells, and other irrigation methods will, therefore, be required to make up the balance of 10 percent to achieve the plan target of 25 percent increase in GNP from agriculture in East Pakistan.

As has been observed, the low-lift pumps have the lowest capital cost and the lowest annual operating cost. It is recommended that the ADC program of low-lift pumps should be enlarged. Tubewells should be installed only in those areas of East Pakistan where low-lift pumps cannot be installed. For an estimated increase of Rs. 3,000 million in GNP from agriculture, tubewells and lift pumps will be required to contribute Rs. 1,200 million. The increase will require an estimated 30 MAF of additional water in five years to be provided from tubewells and lift pumps. This can be achieved by providing pumping capacity of 9 MAF in the fifth year. This would require delivery capacity of 54,000 cusecs for both lift pumps and tubewells. It is recommended that 15,000 cusec capacity be provided by tubewells and 39,000 cusec capacity by lift pumps. At an average capacity of 1.5 cusec, 10,000 tubewells and 26,000 low-lift pumps are needed to achieve the required growth in GNP from agriculture.

Before implementing such a large program for installation of tubewells, an inventory of ground water resources in East Pakistan is necessary. An extensive survey should be carried out to determine the quantity and quality of the available ground water. The two main public

organizations presently utilizing ground water are the EPADC and the EPWAPDA. Coordination between EPADC and EPWAPDA for a ground water survey is essential to avoid duplication of efforts.

The areas in East Pakistan where suitable ground water is available are the districts of Dinajpur, Rangpur, Mymensingh, Comilla, Pabna, and Rajshahi. It is recommended that the installation of tubewells be assumed by the private sector in these districts. As the individual farmers do not have sufficient resources and facilities to install a tubewell, an incentive should be provided for formation of cooperative societies similar to those existing in Comilla and other parts of East Pakistan. Credit may be provided to these societies but it should be recovered from the farmers at a low interest rate in a period of about 10 years. The operational cost of the tubewell can be recovered by the farmers in full.

Consolidation of holdings is another factor which is bound to increase agricultural production. This would make it easier for the farmers to construct field channels and would increase irrigation efficiency.

CHAPTER 5

TUBEWELLS IN WEST PAKISTAN

The main sources of water for irrigation in West Pakistan are:

(a) Rivers and their tributaries. About 40 MAF of water now passes unused into the Arabian Sea during the periods of high runoff. This runoff could be stored for later use. The amount of unused water passing into the sea will be reduced to about 30 MAF after Tarbela Dam is completed.

(b) Ground water reservoirs

The possibilities of the development and use of additional surface supplies are being investigated by WAPDA and are beyond the scope of this report, so they will not be considered here.

One of the world's largest ground water reservoirs is under the plains of Bari, Rechna, Chaj, and Thal, Doabs, Bahawalpur, Sind, and the areas under the command of the Swat and Kabul River System. This chapter deals with the utilization of this ground water reservoir by tubewells to meet irrigation requirements in West Pakistan.

5.1 Progress of Installation of Private Tubewells

In order to use the underground water reservoir, installation of tubewells was started on a limited scale in Bari Doab, around Lahore in 1938. During the early years progress was slow and by the end of 1954, according to a survey by the Farm Mechanization Committee, there were only 1,780 [6] tubewells in West Pakistan. But starting in 1960 tubewells became a popular source of irrigation water and their installation rate increased rapidly. By the end of 1963 there were about 22,900 private tubewells in West Pakistan, see Table 5.1. The progress

TABLE 5.1

INSTALLATION PROGRESS OF PRIVATE TUBEWELLS IN WEST PAKISTAN (Yearly Basis)
(Based on Survey Data)

Division	1954	1954-60	1961	1962	1963	1964	1965	1966	1967	1968	1969	Total
Peshawar and Malakand	150	415	107	107	171	171	171	256	171	192	171	2,082
D. I. Khan	10	-	11	23	57	91	159	45	80	23	91	590
Rawalpindi	10	57	16	32	146	195	178	243	535	486	605	2,503
Sargodha	210	1,600	732	1,135	439	1,245	1,172	1,538	2,051	1,062	342	11,526
Lahore	340	1,032	957	1,191	1,935	2,424	3,189	3,890	3,423	4,231	3,005	25,617
Multan	410	2,172	1,683	2,536	2,418	3,366	3,058	3,556	3,556	3,105	2,307	28,167
Bahawalpur	60	525	101	34	336	571	839	1,209	537	269	45	4,526
Khairpur	20	31	52	63	31	31	91	198	188	281	347	1,333
Hyderabad	40	-	-	33	20	34	40	59	85	78	87	476
Quetta	90	136	68	45	227	91	63	68	68	45	30	931
Kalat	-	-	19	-	19	58	57	58	115	173	-	499
Karachi	440	177	81	54	68	27	14	-	27	41	54	983
West Pakistan	1,780	6,145	3,827	5,253	5,867	8,304	9,031	11,120	10,836	9,986	7,084	79,233

of private tubewell installation in different divisions since 1954 is shown in Table 5.1. The average rate of installation of private tubewells from 1965 to 1968 in West Pakistan was about 10,000 per year. During 1969, however, only 7,084 private tubewells were installed, which is the lowest annual rate since 1964. The rate of installation of private tubewells had been increasing every year, reaching a maximum of about 11,100 tubewells in 1966. Since then the installation rate has been continually decreasing, as shown in Fig. 6.

The decline in the growth rate of private tubewells may be attributed to several factors. One of the factors may be the additional water made available by the completion of Mangla Dam and the Link canals while the water supplies in the eastern rivers were still continuing. Water in these rivers was available during 1968-1969 even in some non-perennial canals.

In addition, over the last few years, much of the canal irrigated area in Chaj Doab, Tahl Doab, Rechna Doab, and Bari Doab has been covered by SCARPs. The public SCARPs also tend to decrease the growth of private tubewells.

As stated, growth rate of private tubewells in 1969 was the lowest since 1964. The factors responsible for this decline in the rate of growth, in addition to the availability of additional water and the public tubewells, may be listed as follows:

(a) Near saturation in some area.

(b) Ban on new connections for tubewells.

(c) New electric tarrif.

With the implementation of the Indus Basin Treaty in 1970, the water available in canals has been reduced. This, coupled with low

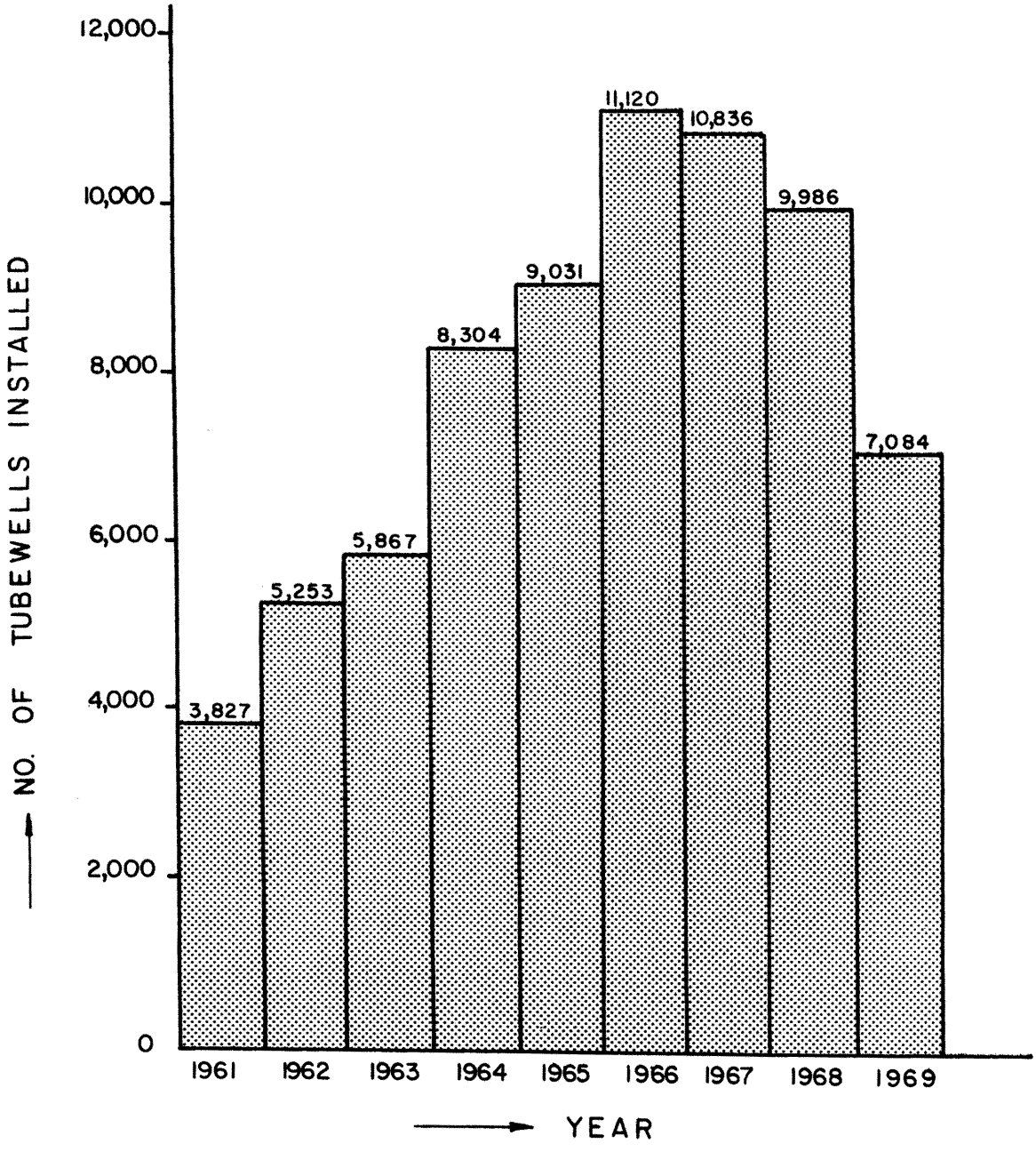

Figure 6 Number of private tubewells installed annually in West Pakistan

rainfall in 1969, has created water panic. This is bound to stimulate farmers to install tubewells. A large number of private tubewells are expected to be installed this year (1970). But the potential areas for private tubewell development are decreasing. Chaj Doab is completely under SCARP. Thal Doab (Muzaffargarh) is also covered by SCARP. Rechna Doab is partly covered by SCARP but most of the areas outside SCARP projects are saline. The major concentration of private tubewells has taken place in Bari Doab. Consequently, it is doubtful whether the rate of installation of private tubewells achieved during the Third Plan can be maintained unless special efforts are made to achieve this growth.

Private tubewell development has been most rapid in the Bari and Rechna doabs, where some of the best farming areas are found and where most of the early initiative was shown. The rate of installation of private tubewells is lower in Thal Doab, the Indus Right Bank, and the Lower Indus. The density of private tubewells by tehsil at the close of 1969 is shown in Fig. 7.

The present growth in the number of tubewells cannot be maintained indefinitely. It is a general observation that water table in the tubewell concentration areas has been gradually going down which is obviously due to the fact that recharge to the ground water reservoir is not sufficient. If this condition persists some of the tubewells may have to be abandoned. More canal water supplies will consequently be required to keep up the agricultural growth brought about by the tubewells in such areas.

PLATE IV

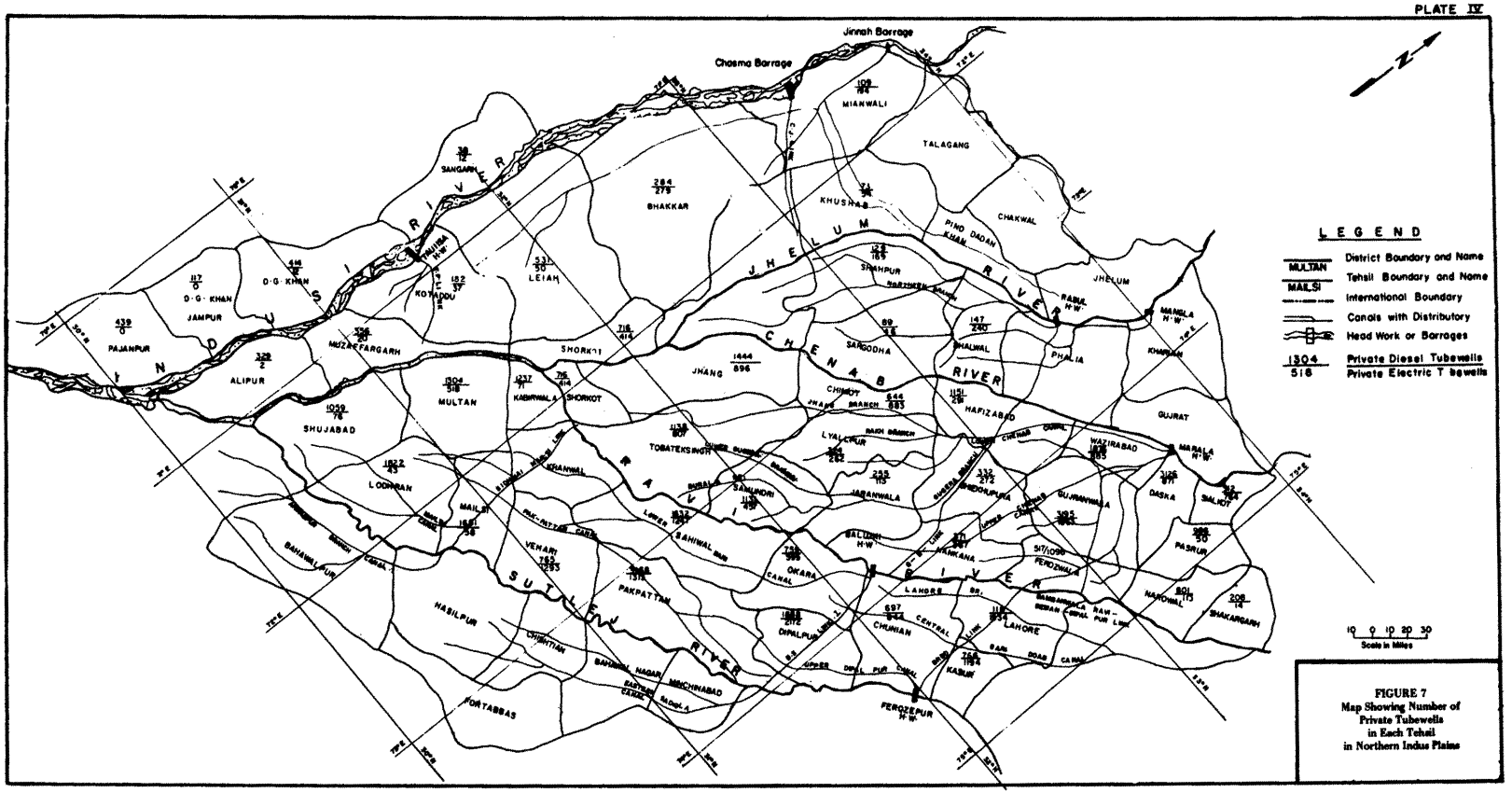

FIGURE 7
Map Showing Number of Private Tubewells in Each Tehsil in Northern Indus Plains

5.2 Private and Government Tubewells

The distribution of public and private tubewells by division in 1969 is given in Table 5.2.

At the end of 1969 there were 87,752 tubewells in West Pakistan, of which 79,233, or 90 percent, were privately owned and 8,519 were operated by government agencies. About 36 percent of all the private tubewells are located in the Multan division, 33 percent in the Lahore division, and 15 percent in the Sargodha division, which constitutes about 83 percent of all private tubewells in West Pakistan.

The public tubewells in West Pakistan have been mainly installed by WAPDA, the Irrigation Department, and the Agricultural Department. The Irrigation Department has installed 1,327 tubewells under the "Rasul Tubewell Scheme" in addition to installing tubewells in several other districts of West Pakistan.

The WAPDA tubewells are installed under "Salinity Control and Reclamation Projects" known as SCARPs. A total of 6,304 tubewells have been installed under several SCARPs. Details of installation of SCARP-WAPDA tubewells are given in Table 5.3, which shows that only 4,143 tubewells were in operation as of 1969. The SCARP tubewells need electric transmission facilities to supply power. Only 4,143 of the 6,304 SCARP tubewells installed had electricity provided as of 1969. The highest concentration of public tubewells is in the division of Lahore where the First Scheme (SCARP-I) is in operation.

In Sind, the ground water is generally saline, but there is a belt of sweet water in the irrigated areas. The small number of private tubewells in the Sind is probably due to big land holdings and tenant farmers with low incentive. When holdings are large, agriculture is

TABLE 5.2

PRIVATE AND GOVERNMENT TUBEWELLS IN WEST PAKISTAN
(1969) (Based on Survey Data)

Division	Private Tubewells		Government Tubewells		Total
	Number of Tubewells	Percent	Number of Tubewells	Percent	
Peshawar and Malakand	2,082	2.6	73	0.3	2,155
D. I. Khan	590	0.8	105	1.2	695
Rawalpindi	2,503	3.3	875	10.4	3,378
Sargodha	11,526	14.6	1,610	19.2	13,136
Lahore	25,617	32.6	3,202	37.9	28,819
Multan	28,167	35.6	1,843	21.4	30,010
Bahawalpur	4,526	4.8	174	2.2	4,700
Khairpur	1,333	1.8	540	6.4	1,873
Hyderabad	476	0.6	23	0.2	499
Quetta	931	1.3	55	0.7	986
Kalat	499	0.7	5	-	504
Karachi	983	1.3	14	0.1	997
West Pakistan	79,233	100.0	8,519	100.0	87,752

TABLE 5.3

SCARP (WAPDA) TUBEWELLS*

SCARP NO.	Project	Number of Tubewells		
		Installed	Electrified	Operated in 1969
I	(Central Rechna Doab)	1,796	1,796	1,796
II	(Chaj Doab)			
	Lalian	163	163	163
	Mona	138	138	138
	Khadir	213	213	213
	U.J. Scheme	884	884	884
III	(Lower Thal)			
	Alipur	542	122	102
	Kot Adu	523	-	-
	Rangpur	570	-	-
IV	(Upper Rechna)			
	Mangtanwala	311	311	307
	Muridke	624	-	-
	Subtotal	5,764	3,627	3,603
**	SCARP Khairpur	540	540	540
	TOTAL	6,304	4,167	4,143

* As reported by the Reclamation Division of WAPDA.

** WAPDA has not assigned any number to SCARP Khairpur.

usually less intensified due to poor management. Even in areas of the Sind where ground water is not saline private tubewells have not been initiated.

In the divisions of Quetta, Kalat, and Karachi there is a problem of ground water recharge. In Karachi the water is also generally saline. Consequently, the growth of private tubewells in these division has been less than other areas of West Pakistan.

5.3 Classification of Tubewells

Tubewells can be classified according to the following categories:

(a) Power source.

(b) Discharge capacity.

(c) Motor/Engine capacity.

(d) Type of strainer used.

(e) Size of blind pipe.

(f) Depth of bore.

(g) Size of holdings owned by tubewell owners.

(h) Size of area irrigated.

a. Distribution of tubewells by power source

Out of 79,233 private tubewells in West Pakistan, 48,520 are powered by diesel engines. The rest are electrically operated. Practically all the government tubewells are powered by electricity.

The distribution of tubewells according to power source and by division is shown in Table 5.4.

As seen from Table 5.4 most of the tubewells in the Peshawar, D.I. Khan, Rawalpindi, Hyderabad, and Karachi divisions are powered by electricity. In the Sargodha, Lahore, Multan, Bahawalpur, Quetta, and

TABLE 5.4

DISTRIBUTION OF PRIVATE AND PUBLIC TUBEWELLS BY POWER SOURCE
(Based on Survey Data) (1969)

Division	Government Tubewells Electric	Private Tubewells Electric Number	Private Tubewells Electric Percent	Private Tubewells Diesel Number	Private Tubewells Diesel Percent	Private Tubewells Total
Peshawar and Malakand	73	2,007	6.5	75	0.2	2,082
D. I. Khan	105	491	1.6	99	0.2	590
Rawalpindi	875	1,413	4.6	1,090	2.2	2,503
Sargodha	1,610	4,990	16.2	3,536	13.5	11,526
Lahore	3,202	10,560	34.4	15,057	31.0	25,617
Multan	1,843	8,150	26.5	20,017	41.3	28,167
Bahawalpur	174	1,121	3.7	3,405	7.0	4,526
Khairpur	540	482	1.6	851	1.7	1,333
Hyderabad	23	293	1.0	183	0.4	476
Quetta	55	379	1.2	552	1.1	931
Kalat	5	180	0.6	319	0.7	499
Karachi	14	647	2.1	336	0.7	983
West Pakistan	8,519	30,713	100.0	48,520	100.0	79,233

Kalat divisions most of the tubewells are diesel operated. In West Pakistan 61 percent of the private tubewells are diesel powered, and 39 percent are electrically powered.

The success of private tubewells has led to an increasing awareness on the part of farmers regarding the advantages of using ground water. It is for this reason that in the past few years farmers have installed a large number of tubewells. Also, they have not hesitated in installing the more expensive diesel tubewells wherever electric supplies were not available.

b. Distribution of tubewells by discharge capacity

As indicated by Table 5.5, the delivery capacity of private tubewells varies from less than 0.25 cusec to more than 3 cusec, but most of the private tubewells are in the range of .75 to 1.5 cusec capacity. The average capacity of a private tubewell is about one cusec. About 52 percent of the private tubewells have delivery capacities of more than one cusec. Four percent of the tubewells have delivery capacities of more than 2 cusec. The combined delivery capacities of all private tubewells have been calculated at about 82,200 cusec.

Table 5.6 shows the delivery capacity of SCARP tubewells. The 6,566 tubewells* installed in various projects have a combined delivery capacity of 23,000 cusec. Only 4,405* tubewells have been commissioned so far and these represent a combined delivery of about 15,000 cusec. Other public tubewells in West Pakistan not accounted for in Table 5.6 are estimated to have a combined delivery capacity of about 4,000 cusec. So the combined delivery capacity of the public tubewells is about 27,000 cusec.

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*In SCARP I, 262 tubewells installed by the Irrigation Department are also included.

TABLE 5.5

DISTRIBUTION OF PRIVATE TUBEWELLS ACCORDING TO DISCHARGE CAPACITY
(Based on Survey Data) (1969)

Division	No. of Tube-wells	Less than 0.25	Percent of Total										Average Capacity (Cusec)	Total Capacity (Cusec)
			0.26-0.50	0.51-0.75	0.76-1.00	1.01-1.25	1.26-1.50	1.51-1.75	1.76-2.00	2.01-2.50	2.51-3.00	3.01 & above		
Peshawar and Malakand	2,082	41.99	51.38	1.10	1.66	1.10	1.66	1.10	-	-	-	-	0.33	683
D. I. Khan	590	-	-	5.88	27.45	15.69	35.29	7.84	7.84	-	-	-	1.18	698
Rawalpindi	2,503	7.48	19.73	27.89	20.41	14.97	7.48	0.68	1.36	-	-	-	0.74	1,849
Sargodha	11,526	0.32	2.91	13.27	22.65	27.51	17.48	9.39	1.29	2.91	2.27	-	1.14	13,109
Lahore	25,617	8.49	7.65	16.30	18.91	17.65	11.85	6.97	8.40	3.28	0.42	0.08	1.03	26,281
Multan	28,167	0.43	1.96	12.64	28.69	28.95	16.14	5.81	4.87	0.51	-	-	1.10	30,895
Bahawalpur	4,526	6.02	3.01	9.02	9.02	17.29	15.04	24.81	9.77	4.51	0.75	0.75	1.28	5,810
Khairpur	1,333	2.38	10.32	7.14	18.25	28.57	25.40	3.17	3.17	0.79	0.79	-	1.08	1,435
Hyderabad	476	4.48	10.45	10.45	20.90	20.90	14.93	5.97	11.94	-	-	-	1.06	504
Quetta	931	2.70	75.68	21.62	-	-	-	-	-	-	-	-	0.43	400
Kalat	499	15.38	84.62	-	-	-	-	-	-	-	-	-	0.34	167
Karachi	983	25.00	65.00	7.50	2.50	-	-	-	-	-	-	-	0.35	347
West Pakistan	79,233													82,179
Weighted Averages		5.13	8.20	13.69	21.48	22.21	14.03	7.30	5.42	1.94	0.52	0.07	1.04	

TABLE 5.6

DELIVERY CAPACITY OF SCARP (WAPDA) TUBEWELLS (1969)

Project	Tubewells Installed Number	Tubewells Installed Capacity (cfs)	Tubewells in Operation Number	Tubewells in Operation Capacity (cfs)
SCARP-I	2,058*	6,000	2,058*	6,000
SCARP-II	1,398	5,652	1,398	5,652
SCARP-III	1,635	6,240	102	392
SCARP-IV	935	3,446	307	1,134
SCARP-V	540	1,674	540	1,674
Khairmur	6,566*	23,012	4,405*	14,852

c. Distribution of private tubewells by motor/engine capacity

A classification of private tubewells has been made according to horsepower of their motors/engines and is summarized in Table 5.7.

The capacity of the motor/engine depends on the quantity of water to be pumped and total head. Thus in the Peshawar and Malakand divisions where almost 92 percent of the tubewells have a delivery capacity of less than 0.5 cusec, 87 percent of the tubewells have a motor/engine capacity of less than 10 hp. In Multan Division, where about 56 percent of the private tubewells have a delivery capacity of more than one cusec, about 84 percent of the tubewells have a motor/engine capacity of more than 15 hp. In West Pakistan almost 46 percent of the private tubewells have a motor/engine capacity ranging from 15 to 20 hp.

*In SCARP I, 262 tubewells installed by the Irrigation Department are also included.

TABLE 5.7

DISTRIBUTION OF PRIVATE TUBEWELLS ACCORDING TO HORSEPOWER
(Based on Survey Data) (1969)

Division	No. of Tube-wells	Percentage of Total (Horsepower)						
		Up to 5	5-10	11-15	16-20	21-25	26-30	Above 30
Peshawar and Malakand	2,082	65.19	21.55	2.76	8.29	0.55	1.10	0.55
D. I. Khan	590	7.84	1.96	11.76	29.41	33.33	13.73	1.96
Rawalpindi	2,503	3.40	18.37	21.77	55.10	0.68	-	0.68
Sargodha	11,526	2.27	12.94	30.10	41.42	12.30	0.32	0.65
Lahore	25,617	8.24	14.45	28.32	45.63	2.94	0.34	0.08
Multan	28,167	2.39	3.33	9.74	52.86	30.32	1.02	0.34
Bahawalpur	4,526	1.50	6.77	10.53	51.88	24.06	2.26	3.01
Khairpur	1.333	8.73	7.14	10.32	54.76	12.70	3.97	2.38
Hyderabad	476	5.97	4.48	5.97	64.18	17.91	1.49	-
Quetta	931	8.11	2.70	-	8.11	13.51	10.81	56.76
Kalat	499	7.69	30.77	23.08	30.77	7.69	-	-
Karachi	983	5.00	2.50	50.00	20.00	5.00	7.50	10.00
West Pakistan	79,233	6.20	9.69	19.42	46.56	15.77	1.08	1.30

d. Distribution of private tubewells by type of strainer used

Table 5.8 shows the classification of private tubewells according to the type of strainer used.

Two types of strainers, namely the coir string and brass, are being used in private tubewells in West Pakistan. The coir string type of strainer is more popular because of its low cost and easy availability. Table 5.8 shows that of the installed tubewells, 83.5 percent of them have coir string strainers and 6 percent of them have brass strainers.

About 9 percent of private tubewells have no strainer which exclusively represents those wells which have been developed on open wells. Although this type of well is not a tubewell, it has been included in this report because it involves mechanical pumping from the ground water aquifer. This type of tubewell has generally been installed in the Peshawar, Malakand, Quetta, and Karachi divisions.

e. Distribution of private tubewells by diameter of the blind pipe

Table 5.9 shows the distribution of private tubewells according to the diameter of the blind pipe used.

Table 5.9 shows that about 60 percent of the private tubewells have used 6-inch diameter blind pipes. The next popular size of blind pipe is the 5-inch diameter which comprises about 17 percent of the total.

f. Distribution of private tubewells by depth of bore

Tubewells are classified according to depths of bore for the various divisions as shown in Table 5.10. Table 5.10 shows that about 40 percent of tubewells have a depth of bore of 100 ft or less and the other

TABLE 5.8

PRIVATE TUBEWELLS ACCORDING TO TYPE OF STRAINER
(Based on Survey Data) (1969)

Division	No. of Tube-wells	Percent of Total			
		No Strainer*	Coin String	Brass	Others
Peshawar and Malakand	2,082	89.86	1.19	8.93	-
D. I. Khan	590	2.18	14.89	82.98	-
Rawalpindi	2,503	3.85	94.23	1.92	-
Sargodha	11,526	3.30	95.60	1.10	-
Lahore	25,617	6.30	91.99	1.71	-
Multan	28,167	0.21	85.56	10.19	4.04
Bahawalpur	4,526	14.74	74.74	10.52	-
Khairpur	1,333	-	93.80	6.20	-
Hyderabad	476	-	69.49	30.51	-
Quetta	931	95.57	3.54	0.89	-
Kalat	499	100.00	-	-	-
Karachi	983	96.00	4.00	-	-
West Pakistan	79,233	8.87	83.54	6.15	1.44

* Developed on open wells.

TABLE 5.9

DISTRIBUTION OF PRIVATE TUBEWELLS ACCORDING TO THE DIAMETER OF THE BLIND PIPE
(Based on Survey Data) (1969)

Division	No. of Tube-wells	Percent of Total							
		Size of Blind Pipe - inches							
		2	3	4	5	6	7	8	& Above
Peshawar and Malakand	2,082	33.34	40.42	2.38	14.28	9.52	-	-	-
D. I. Khan	590	-	-	-	21.90	78.10	-	-	-
Rawalpindi	2,503	-	6.58	24.80	37.40	28.40	1.41	1.41	-
Sargodha	11,526	-	-	6.69	17.21	53.18	2.15	18.63	2.15
Lahore	25,617	-	0.34	5.72	15.83	70.37	3.70	4.04	-
Multan	28,167	-	0.13	3.09	16.47	67.32	2.14	10.84	-
Bahawalpur	4,526	1.55	-	4.65	3.01	75.96	8.52	6.30	-
Khairpur	1,333	-	-	4.85	6.80	58.25	-	29.12	0.98
Hyderabad	476	-	1.85	1.85	12.80	79.80	1.85	1.85	-
Quetta	931	-	14.28	77.14	8.58	-	-	-	-
Kalat	499	-	23.60	70.50	5.90	-	-	-	-
Karachi	983	-	14.00	50.00	36.00	-	-	-	-
West Pakistan	79,233								
Weighted Average		0.84	2.19	8.64	16.90	59.65	2.55	8.78	0.45

TABLE 5.10

DISTRIBUTION OF PRIVATE TUBEWELLS ACCORDING TO DEPTH OF BORE
(Based on Survey Data) (1969)

Division	No. of Tube-wells	Percent of Total Depth of Bore-feet					Average Bore Depth (feet)
		Less than 100	100-200	201-300	301-400	Below 400	
Peshawar and Malakand	2,082	91.71	3.87	2.21	1.10	1.10	20.43
D. I. Khan	590	35.29	64.71	-	-	-	117.75
Rawalpindi	2,503	95.24	4.76	-	-	-	70.82
Sargodha	11,526	31.07	61.81	5.50	1.62	-	129.56
Lahore	25,617	58.91	38.32	2.44	0.34	-	107.08
Multan	28,167	21.43	73.27	4.36	0.34	0.60	136.24
Bahawalpur	4,526	15.04	73.68	10.53	0.75	-	159.46
Khairpur	1,333	57.14	42.06	0.79	-	-	101.50
Hyderabad	476	32.84	59.70	7.46	-	-	131.15
Quetta	931	54.05	45.95	-	-	-	66.73
Kalat	499	92.31	7.69	-	-	-	26.73
Karachi	983	25.00	75.00	-	-	-	130.72
West Pakistan	79,233						119.73
Weighted Average		40.41	54.96	3.85	0.54	0.24	

55 percent have a depth between 100 to 200 ft. Practically all the tubewells have a depth less than 200 ft. Deep private tubewells are almost nonexistent.

g. Distribution of private tubewells by size of holdings owned by tubewell owners

Table 5.11 shows the distribution of private tubewells according to the size of holdings owned by the tubewell owner. It shows that owners having less than 10 acres of land have installed about 11 percent of the total tubewells. Farmers who own 11 to 50 acres of land comprise the largest group of tubewell owners.

Table 5.12 shows the total area owned by tubewell owners in West Pakistan according to different holding sizes. Tubewell owners in West Pakistan hold an area of 4.3 million acres.

The tubewell owners holding between 11 to 50 acres hold an area of about 1,380 thousand acres which is about 32 percent of the total area owned by tubewell owners. The total area in different sized holdings by division is given in Appendix D.

It appears that main factors that govern the rate of private tubewell installation relate essentially to the farmer's financial resources which in turn is related to farm size and to the form of tenure under which the farms are operated.

h. Distribution of private tubewells by size of area irrigated

Table 5.13 shows the classification of private tubewells by the size of the area irrigated by these tubewells.

This table indicates that there are a few tubewells that irrigate areas of less than 10 acres. The largest single class of private tubewells is that group which irrigates between 11 to 100 acres of land.

TABLE 5.11

PRIVATE TUBEWELL DISTRIBUTION ACCORDING TO SIZE OF HOLDING
(Based on Survey Data) (1969)

Division	No. of Tube-wells	Percent of Total Size of Holding Owned by Tubewell Owners (Acres)										
		Up to 10	11-25	26-50	51-75	76-100	101-150	151-200	201-300	301-500	501 & Above	
Peshawar and Malakand	2.082	71.27	15.47	7.18	3.31	2.21	0.55	-	-	-	-	14.0
D. I. Khan	590	1.96	13.73	29.41	13.73	5.88	23.53	1.96	1.96	7.84	-	102.59
Rawalpindi	2,503	31.29	43.54	17.01	4.08	2.72	0.68	-	0.68	-	-	24.69
Sargodha	11,526	9.06	25.24	21.36	14.89	8.41	12.62	4.85	2.91	0.65	-	68.25
Lahore	25,617	11.34	39.92	32.35	10.25	3.70	2.18	0.08	0.08	0.08	-	34.98
Multan	28,167	2.48	23.40	31.94	18.27	12.81	7.00	2.22	1.45	0.34	0.99	60.83
Bahawalpur	4,526	1.50	19.55	20.57	15.79	12.78	10.53	4.51	4.51	2.26	-	83.16
Khairpur	1,333	3.97	7.94	21.43	7.94	18.25	9.52	9.52	11.11	7.14	3.17	149.98
Hyderabad	476	2.99	8.96	14.93	19.40	19.40	14.93	2.99	7.46	7.46	1.49	127.92
Quetta	931	-	13.51	45.95	16.22	16.22	5.41	-	2.70	-	-	59.97
Kalat	499	38.46	26.92	19.23	11.54	3.85	-	-	-	-	-	25.69
Karachi	983	10.00	22.50	42.50	7.50	7.50	7.50	2.50	-	-	-	49.52
West Pakistan	79,233											
Weighted Average		11.24	28.44	26.52	13.14	8.45	5.81	1.84	1.58	0.81	0.17	54.27

TABLE 5.12

SIZE OF HOLDINGS OWNED BY PRIVATE TUBEWELL
(Projection Based on Survey Data) (1969)

Holding Size (Acres)	*Total Area (Thousand Acres)	Percentage of Total Area
Less than 10	53.0	1.23
11-25	445.9	10.36
26-50	934.5	21.72
51-75	735.1	17.09
76-100	640.7	14.89
101-150	648.4	15.07
151-200	293.5	6.82
201-300	312.5	7.26
301-500	184.4	4.29
501 & above	54.6	1.27
TOTAL	4,302.6	100.00

* Total area refers to land owned by tubewell owners including land unsuitable for cultivation.

TABLE 5.13

DISTRIBUTION OF PRIVATE TUBEWELLS ACCORDING TO SIZE OF AREA IRRIGATED, 1969
(Based on Survey Data)

	No. of Tube-wells	Percent of Total										
		Upto 10	11-25	26-50	51-75	76-100	101-150	151-200	201-300	301-500	501 and Above	Average Area Irrigated
								(Acres)				
Peshawar and Malakand	2,082	51.93	29.83	10.50	2.76	3.31	1.10	-	0.55	-	-	18.64
D.I. Khan	590	-	11.76	19.61	19.61	9.80	33.53	5.88	1.96	7.84	-	108.52
Rawalpindi	2,503	19.73	38.10	25.17	5.44	3.40	6.80	0.68	-	0.68	-	36.71
Sargodha	11,526	4.53	17.15	23.62	15.53	12.62	15.21	4.53	5.83	0.97	-	76.81
Lahore	25,617	2.61	24.20	35.21	19.58	10.50	5.97	1.26	0.50	0.17	-	51.41
Multan	28,167	1.37	16.31	31.51	21.18	14.01	11.10	2.31	1.45	0.60	0.17	65.01
Bahawalpur	4,526	2.26	15.04	30.83	15.79	11.28	11.28	3.01	6.77	3.01	0.75	88.31
Khairpur	1,333	2.38	7.14	14.29	12.70	12.70	15.87	12.70	7.94	7.94	6.35	177.30
Hyderabad	476	2.99	4.48	16.42	17.91	16.42	8.96	16.42	4.48	10.45	1.49	142.21
Quetta	931	5.41	16.22	40.54	24.32	2.70	5.41	5.41	-	-	-	55.20
Kalat	499	38.46	30.77	23.08	3.85	3.85	-	-	-	-	-	20.77
Karachi	983	-	22.50	37.50	10.00	12.50	7.50	5.00	2.50	2.50	-	69.43
WEST PAKISTAN	79,233											64.50
Weighted Average		5.87	20.21	29.70	17.68	11.30	9.14	2.73	1.90	1.12	0.35	

Almost 94 percent of the tubewells irrigate areas under 150 acres. The average area irrigated by a private tubewell is about 64 acres.

Table 5.14 shows the total area irrigated by private tubewells in each category of holding sizes.

As indicated from Table 5.14, the maximum area irrigated by tubewell falls between 26 to 150 acres. The area in this category is about 75 percent of the total irrigated area. The different categories of irrigated areas are shown in Appendix D by division.

5.4 Private Tubewell Financing in West Pakistan

About 84 percent of the private tubewells installed have been paid for by the farmers. The remaining 16 percent of the private tubewells have been financed by loans from various agencies such as the Agricultural Development Bank of Pakistan. Private tubewells represent an estimated investment of Rs. 689 million; almost Rs. 565 million have been invested by the farmers. This indicates the great contribution the farmers have made in the development of water potential in West Pakistan.

The credit advanced for about 16 percent of the private tubewells is to be repaid in full by the farmers at an interest rate of 8 percent. These figures indicate the difficulties farmers have in obtaining credit.

The procedure for granting credit by the Agricultural Development Bank (ADBP) is quite cumbersome. It must be simplified. The following points if implemented may give incentive to farmers to obtain credit from the bank.

1. At present only the cost of boring and civil works is paid in cash and the required pipes and engines are supplied through

TABLE 5.14

AREA IRRIGATED BY PRIVATE TUBEWELLS, 1969
(Projection Based on Survey Data)

Size of Area Irrigated (Acres)	*Irrigated Area (Thousand Acres)	Percent of Total Area Irrigated
Less than 10	26.2	0.52
11-25	295.1	5.83
26-50	910.9	18.00
51-75	901.7	17.80
76-100	813.3	16.07
101-150	950.8	18.79
151-200	358.4	7.08
201-300	405.6	8.01
301-400	263.7	5.21
401-500	136.2	2.69
TOTAL	5,061.9	100.00

* Irrigated area refers to land that had been irrigated during 1969.

approved dealers. In this case the farmer has no choice but to get the materials from these dealers at their price. If he were to purchase the same from open market the cost could be reduced.

2. The current interest rate of 8% has been introduced since July 1, 1969. Previously the rate of interest was 7%. The State Bank of Pakistan gives loan to ADBP at a rate of 3% while the IDA Loans are advanced 4%. To this is added the cost of administration which is 3%. This gives the interest rate at 6% or 7%. If the cost of administration can be reduced and more money at low interest rate can be provided by the Government for advancement to prospective tubewell owners the interest rate could be reduced to about 6%.

3. The applicants must have a minimum development area which can be irrigated from a tubewell, which is as follows:

Size of Tubewell	Minimum Development Area Required
¼ Cusec Capacity	12½ to 25 acres
½ " "	25 to 50 "
1 " "	50 to 100 "
1½ " "	75 to 150 "
2 " "	100 to 200 "

This condition should be reviewed. A tubewell of ½ cusec capacity will not efficiently serve an area of 40-50 acres. The amount of water available will be deficient, efficiency of irrigation will be less and the effect of deterioration will be felt more severely in addition to large conveyance losses due to slower movement of water. So loans

should be advanced for one cusec capacity tubewells for holdings of 25 acres or more.

5.5 Private Tubewells Installed on Canal-Irrigated Lands

Table 5.15 gives the distribution by division of tubewells installed on the canal-irrigated lands.

About 42 percent of the private tubewells are installed on canal-irrigated lands; their main function is to supplement the canal water. These tubewells represent a delivery capacity of 37,782 cusec and command an area of 2.5 million acres.

Of the 33,237 private tubewells installed on canal-irrigated lands, 13,027 are installed on such lands where tubewell supplies are additional to seasonal canals; 20,210 tubewells supply additional water to perennial canals. The distribution of private tubewells installed on seasonal and perennial canal-irrigated lands is given by division in Table 5.16.

5.6 Cropping Intensity on Tubewell-Irrigated Farms

The area irrigated by private tubewells and cropping intensities on private tubewell farms in different divisions is given in Table 5.17.

Private tubewells in West Pakistan serve a total cultivable commanded area of 4.2 million acres. About 2.6 million acres were sown during Rabi (1968) and 2.5 million acres during Kharif (1969), giving a total cultivated area of 5.1 million acres on private tubewell farms. The average cropping intensity in various divisions of West Pakistan ranges from 81 percent in the Kalat Division to 151 percent in the Lahore Division. The average cropping intensity on private tubewell-irrigated farms in West Pakistan is 121 percent.

TABLE 5.15

PRIVATE TUBEWELLS INSTALLED ON CANAL-IRRIGATED LANDS (1969)
(Projection Based on Survey Data)

Division	No. of Tube-wells	Installed on Canal-irrigated Lands	Percent	Total Capacity (Cusec)	Area Commanded (Acres)
Peshawar and Malakand	2,082	35	1.66	26.7	1,700
D.I. Khan	590	174	29.41	214.1	14,200
Rawalpindi	2,503	17	0.68	14.8	1,100
Sargodha	11,526	3,744	49.84	6,739.1	491,900
Lahore	25,617	5,898	23.03	6,394.1	382,400
Multan	28,167	18,930	67.21	21,379.3	1,244,600
Bahawalpur	4,526	953	21.05	1,500.0	64,500
Khairpur	1,333	1,037	77.78	1,082.2	206,400
Hyderabad	476	405	85.07	414.7	60,500
Quetta	931	-	-	-	-
Kalat	499	19	3.85	7.7	1,500
Karachi	983	25	2.50	9.8	800
WEST PAKISTAN	79,233	33,237	41.95	37,782.5	2,469,600

TABLE 5.16

PRIVATE TUBEWELLS INSTALLED IN ADDITION TO SEASONAL AND PERENNIAL CANALS (1969)
(Projections Based on Survey Data)

Division	Tubewell Additional to Seasonal Canals				Tubewell Additional to Perennial Canals			
	Number	Percent	Delivery Capacity (Cusec)	Area Irrigated 1,000 Acres	Number	Percent	Delivery Capacity (Cusec)	Area Irrigated 1,000 Acres
Peshawar and Malakand	-	-	-	-	35	1.66	26.7	1.7
D.I. Khan	58	0.80	74.4	5.7	116	19.61	139.7	8.5
Rawalpindi	17	0.68	14.8	1.1	-	-	-	-
Sargodha	187	1.62	227.5	20.3	5,558	48.22	6,511.6	471.7
Lahore	2,992	11.68	3,551.5	208.0	2,906	11.34	2,842.6	174.4
Multan	8,226	29.11	8,962.3	620.3	10,704	38.00	12,417.0	624.4
Bahawalpur	919	20.30	1,425.2	61.0	34	0.75	74.9	3.4
Khairpur	561	42.06	531.6	110.6	476	35.71	550.5	95.8
Hyderabad	43	8.96	25.5	5.8	362	76.12	389.2	54.7
Quetta	-	-	-	-	-	-	-	-
Kalat	-	-	-	-	19	3.85	7.7	1.5
Karachi	25	2.50	9.8	0.8	-	-	-	-
WEST PAKISTAN	13,027	16.44	14,822.6	1,033.5	20,210	25.51	22,959.9	1,436.1

TABLE 5.17

CROPPING INTENSITY ON PRIVATE TUBEWELL-IRRIGATED LANDS, 1968 and 1969
(Projections Based on Survey Data)

Division	Area in Thousand of Acres				Intensity % of CCA*
	CCA under Tubewells*	Rabi (1968)	Kharif (1969)	Total	
Peshawar and Malakand	28.94	18.02	20.79	38.82	134
D.I. Khan	59.68	43.47	20.56	64.02	107
Rawalpindi	61.60	46.32	45.56	91.88	149
Sargodha	762.56	456.10	429.26	885.34	116
Lahore	873.02	662.24	654.67	1,316.93	151
Multan	1,679.90	919.88	911.25	1,831.21	109
Bahawalpur	368.48	195.13	204.55	399.68	108
Khairpur	185.25	103.40	132.94	236.34	128
Hyderabad	56.24	30.39	37.30	67.69	120
Quetta	55.83	35.20	16.19	51.39	92
Kalat	12.82	6.92	3.45	10.36	81
Karachi	47.09	36.81	31.44	68.25	145
WEST PAKISTAN	4,191.41	2,553.88	2,507.95	5,061.91	121

*Cultivable Commanded Area refers to the land under cultivation on tubewell farms in West Pakistan.

5.7 Sale of Water by Private Tubewell Owners

Table 5.18 shows the number of private tubewells in each holding size from which water is sold. The number is also expressed as a percentage of the total tubewells in each division of holding sizes.

Only 14 percent of the tubewell owners reported sale of water to their neighbors. The sale of water by private tubewell owners varies according to holding size as well as from division to division. About 21 percent of tubewell owners with holding sizes of less than 10 acres sell water to neighboring farmers, while about 4 percent of tubewell owners with holdings greater than 200 acres sell water. Tubewell owners in D.I.Khan, Multan, and Bahawalpur show the maximum percentage of water sales in most holding sizes.

5.8 Operation Period of Private Tubewells for Different Holding Sizes

Table 5.19 shows the average time of operation for private tubewells according to the area owned by the tubewell owners.

As seen from Table 5.19, the average number of days and hours per day of operation of a tubewell varies by the size of the holding. Average hours of operation are lowest (1,491) for holdings of less than 10 acres and highest (3,500) for holdings of more than 200 acres. It can be seen, therefore, that private tubewells presently installed are not being used to the fullest extent.

5.9 Water Pumped Annually

The average operating period of a private tubewell has been estimated at 2,130 hours per year. Depending on rainfall, cropping pattern, and the availability of canal water both during Kharif and Rabi seasons

TABLE 5.18

SALE OF WATER BY PRIVATE TUBEWELL OWNERS, 1969
(Projections Based on Survey Data)

Division	Holding Sizes: Less than 10 Acres		1-25 Acres		26-50 Acres		51-75 Acres		76-100 Acres		101-150 Acres		151-200 Acres		201 Acres and above	
	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent	No.	Per-cent
Peshawar and Malakand	149	10.1	28	8.7	28	18.7	-	-	-	-	-	-	-	-	-	-
D.I. Khan	11	100.0	78	55.6	78	44.8	-	-	33	94.3	10	7.3	10	90.9	55	94.8
Rawalpindi	217	27.5	100	9.2	67	15.8	-	-	-	-	-	-	-	-	-	-
Sargodha	179	16.6	324	11.4	398	16.1	286	16.5	107	11.0	71	4.9	36	6.5	36	8.6
Lahore	580	20.6	785	7.6	450	5.4	45	1.7	21	2.2	-	-	-	-	-	-
Multan	336	48.0	2,150	33.1	2,370	26.6	790	15.5	406	11.4	240	12.2	-	-	-	-
Bahawalpur	33	48.5	100	11.3	165	12.8	165	23.2	33	5.7	65	13.9	33	16.2	-	-
Khairpur	-	-	-	-	20	7.0	-	-	20	8.2	-	-	-	-	-	-
Hyderabad	-	-	-	-	-	-	-	-	7	7.6	-	-	-	-	-	-
Quetta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kalat	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Karachi	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WEST PAKISTAN	1,505	20.6	3,565	15.6	3,576	15.5	1,286	11.8	627	9.2	386	7.8	79	5.0	91	4.4

TABLE 5.19

OPERATION PERIOD OF PRIVATE TUBEWELLS FOR DIFFERENT HOLDING SIZES, (1969)
(Projections Based on Survey Data)

Holding Size (Acres)	Average days of operation			Average hours of operation per day	Average hours of operation per year
	Kharif	Rabi	Total		
Less than 10	106	107	213	7	1,491
11-25	107	106	213	9	1,917
26-50	107	113	220	10	2,200
51-75	112	120	232	10	2,320
76-100	114	125	239	11	2,629
101-150	121	128	249	12	2,988
151-200	130	140	270	12	3,249
201 and above	123	127	250	14	3,500

the operating period of private tubewells varies from place to place. Average hours of operation increase when tubewell owners sell water to their neighbors.

Table 5.20 shows the amount of ground water pumped annually by private tubewells in various divisions of West Pakistan.

Table 5.20 indicates that private tubewells are pumping about 14 MAF per year; public tubewells are pumping an estimated 5 MAF. This gives a total ground water utilization of about 19 MAF per year. The estimated future recharge to the ground water reservoir is about 42 MAF.[22] This estimate of recharge is based on the time when all projects in the Indus Basin including Tarbela Dam have been completed and irrigation intensity has been increased to about 150 percent. Although annual ground water pumpage cannot presently be increased to 42 MAF, it indicates that there is still a vast potential for development of ground water resources in West Pakistan. No restrictions on private tubewell development are foreseen at this time.

5.10 Role of Private Tubewells

Tubewells increase agricultural growth by increasing cropping intensities. Two or three crops can be planted each year instead of one. They also allow cultivation of formerly unused lands. Tubewells also contribute to increased agricultural growth by promoting the cultivation of high value crops, adoption of modern farm practices, efficient use of farm resources, and spreading of fixed farm costs over large acreage and output and thus reducing the cost of cultivation per unit of land or output. Tubewells also help increase yields by

TABLE 5.20

PRIVATE TUBEWELL WATER PUMPED ANNUALLY (1969)
(Based on Survey Data)

Division	No. of tube-wells	Combined Delivery Capacity (cusec)	Number of working days/year (average)	Number of working hrs/ working day (average)	Number working hrs/year (average)	Water pumped annually MAF
Peshawar and Malakand	2,082	683	305	6.7	2,040	0.116
D.I. Khan	590	698	244	12.0	2,920	0.169
Rawalpindi	2,503	1,849	185	9.0	1,670	0.258
Sargodha	11,526	13,109	288	7.7	2,220	2.436
Lahore	25,617	26,282	169	10.3	1,740	3.817
Multan	28,167	30,895	240	10.0	2,400	6.162
Bahawalpur	4,526	5,810	222	8.4	1,868	0.907
Khairpur	1,333	1,435	209	10.3	2,160	0.258
Hyderabad	476	504	307	12.3	3,780	0.159
Quetta	931	400	248	7.0	1,736	0.058
Kalat	499	167	244	7.0	1,708	0.024
Karachi	983	347	342	5.5	1,880	0.055
WEST PAKISTAN	79,233	82,179	224	9.5	2,130	14.419

providing adequate supplies of irrigation water. The effect of private tubewells on land use is shown in Table 5.21.

TABLE 5.21

LAND USE ON PRIVATE TUBEWELL AND NON-TUBEWELL FARMS, 1969

Type of Farm	Total Farm Area (Percentage)	Cultivated Area (Percentage)	Cultivable Waste Area (Percentage)
Farms with tubewells	100	96.4	3.6
Farms without tubewells	100	87.5	12.5

Table 5.21 shows that fallow land and cultivable wastes are reduced by about 9 percent on tubewell farms.

Cropping intensities on tubewell farms are greater than on non-tubewell farms. Under non-tubewell conditions, cropping intensities are sometimes only 50 percent, which means that half of the cultivable land remains unused on these farms each year. Furthermore, on non-tubewell farms crops are sometimes grown with a deficient amount of irrigation water which, in turn, affects yields and causes salinity because the salts are not washed out. It is estimated that a tubewell of only one cusec increases the cropped area by about 40 to 50 percent which increases farm income 40 to 50 percent.

Availability of additional irrigation water supplies appears to encourage farmers to switch from low value crops to high value crops as shown in Table 5.22. Farmers with reliable water supplies tend to decrease maize and other crop production in favor of rice and cotton.

TABLE 5.22

CROPPING PATTERN ON PRIVATE TUBEWELL AND NON-TUBEWELL FARMS, 1969
(Based on Survey Data)

Area	Type of Farm	Cotton	Sugar-cane	Maize	Rice	Wheat	All other crops
		(Percent of total crops grown in 1969)					
West Pakistan	With Tube-well	19.87	4.13	1.22	14.45	40.43	19.90
	Non-tube-well	11.50	3.75	2.00	6.00	35.00	41.75
	% Increase or Decrease	+67	+10	-39	+141	+16	-52
Rice Area (Lahore Division)	With Tube-well	2.08	2.28	0.51	38.59	42.65	13.89
	Non-tube-well	2.00	1.50	1.00	15.30	38.95	41.25
	% Increase or Decrease	+4	+52	-49	+152	+10	-66
Cotton Area (Multan Division)	With Tube-well	36.60	1.45	0.33	2.69	42.65	16.28
	Non-tube-well	20.80	1.00	0.50	0.50	37.60	39.60
	% Increase or Decrease	+76	+45	-34	+435	+15	-59

This may mean, since they are seeking cash crops, that it will increase the farmers' capital position. This, in turn, may lead to savings of capital which may ultimately be reinvested in the country.

Significant increases in acreage growing Kharif crops are observed in West Pakistan, especially the cash crops of cotton, sugarcane, and rice. Kharif crops under tubewell irrigation account for 50 percent of the total cropped area but these crops account for only 43 percent of the total cropped area on non-tubewell farms.

Export of rice coupled with a government supported price has made rice a high-profit crop. Ample and reliable supplies of water available from tubewells make it safe to cultivate and convenient to rotate with wheat in the main agricultural areas of West Pakistan. For these reasons, land used for cultivation of rice in West Pakistan has been increased by 140 percent.

Increased availability of water from tubewells is also responsible for an increase in acreage devoted to cotton.

During Rabi seasons wheat has become a cash crop with the cultivation of Mexi Pak wheat varieties. But these varieties require 30 percent more water than local varieties of wheat. Desi wheat varieties are drought resistant, their yields are only slightly affected by a deficient water supply. In Mexi Pak wheat varieties frequency of irrigation is important as well as depth. Thus, Mexi Pak wheat can be sown and sustained in a convenient manner on tubewell-irrigated farms, which is substantiated by Table 5.22 which shows that wheat cultivated on tubewell farms is 16 percent more than that on non-tubewell farms.

The types of crops on private tubewell irrigated lands are shown in Table 5.23. Table 5.24 shows the cropping pattern on lands where

TABLE 5.23

CROPPING PATTERN ON PRIVATE TUBEWELL-IRRIGATED LANDS, (1969)
(Based on Survey Data)

Division	Percentage of Total Cropped Area						
	Cotton	Maize	Suger-cane	Rice	Wheat	Vegetable and Fodder	Others
Peshawar and Malakand	0.77	34.36	11.02	-	33.96	9.81	10.08
D.I. Khan	4.24	6.83	4.72	8.28	54.99	11.72	9.23
Rawalpindi	2.56	0.40	7.84	28.71	38.77	20.91	0.82
Sargodha	14.32	2.54	11.37	6.94	37.43	24.17	3.23
Lahore	2.08	0.51	2.28	38.59	42.65	13.48	0.41
Multan	36.60	0.33	1.45	2.69	42.56	14.88	1.48
Bahawalpur	28.82	0.80	5.75	4.93	39.66	17.25	2.78
Khairpur	15.30	1.79	3.96	25.15	31.40	8.25	14.13
Hyderabad	36.08	1.78	6.92	2.22	35.05	11.55	6.40
Quetta	-	-	-	-	52.48	15.50	32.02
Kalat	-	-	-	-	61.30	27.78	10.93
Karachi	-	-	-	-	-	82.41	17.58
WEST PAKISTAN (Weighted Averages)	19.87	1.22	4.13	14.45	40.43	16.95	2.96

TABLE 5.24

CROPPING PATTERN ON FARMS WHERE PRIVATE TUBEWELLS ARE THE ONLY SOURCE OF IRRIGATION (1969)
(Based on Survey Data)

Division	Percent of Total Cropped Area						
	Cotton	Maize	Sugarcane	Rice	Wheat	Vegetable and Fodder	Others
Peshawar and Malakand	0.50	34.72	10.11	-	34.00	10.13	10.55
D.I. Khan	5.44	7.56	3.73	5.12	58.43	10.13	9.60
Rawalpindi	2.59	0.40	7.93	28.57	38.75	20.93	0.82
Sargodha	11.71	0.51	6.55	11.35	41.93	22.99	4.96
Lahore	1.85	0.62	2.02	38.65	42.64	13.77	0.46
Multan	34.35	0.53	1.99	5.51	48.26	8.49	0.87
Bahawalpur	26.94	0.95	6.86	5.88	39.26	16.80	3.32
Khairpur	34.10	3.02	4.03	0.14	42.13	11.44	5.13
Hyderabad	28.80	3.96	2.47	1.19	42.95	10.84	9.80
Quetta	-	-	-	-	52.48	15.50	32.02
Kalat	-	-	-	-	61.09	26.09	12.83
Karachi	-	0.18	-	-	-	82.23	17.59
WEST PAKISTAN (Weighted Averages)	14.38	1.25	3.61	18.77	42.55	16.32	3.13

private tubewells are the only source of irrigation. Tables 5.25 and 5.26 show the cropping pattern on farms where tubewells are in addition to perennial canals and seasonal canals, respectively. Significant increases in cotton and sugarcane are observed on farms where tubewells are used in addition to perennial canals. The area used for different types of crops in each division of West Pakistan on farms served by private tubewells is shown in Table 5.27.

Areas growing crops like pulses and millits (included under "others" category in the tables) have been reduced by one-half on tubewell-irrigated farms. These crops have poor yields and are farmed under conditions of short water supply.

It has been observed during this study that the yields of principal crops are higher on tubewell-irrigated farms than on non-tubewell-irrigated farms including farms irrigated by canals. Higher yields are possible on tubewell-irrigated farms because more control over the supply of irrigation water can be exercised and this water can be used when it is needed. Previously, relatively larger areas were cultivated than the available water supply could sustain; this, coupled with canal closures, resulted in crop failures and/or low yields due to drought stress. Deep irrigation and decreased waterlogging due to lowering of the water table through pumping have improved soil conditions. These are factors responsible for increased yields from tubewell farms. It is not possible to isolate the net contribution of tubewell water on higher yields because yield also depends on other inputs such as fertilizer, high yield seeds, and pesticides. Without the addition of tubewell water to the canal water supply cropping intensity cannot be increased. However, an increased cropping intensity cannot be maintained

TABLE 5.25

CROPPING PATTERN ON FARMS WHERE PRIVATE TUBEWELLS ARE AN ADDITION TO PERENNIAL-CANAL IRRIGATION (1969)
(Based on Survey Data)

Division	Percent of Total Cropped Area						
	Cotton	Maize	Sugarcane	Rice	Wheat	Vegetable and Fodder	Others
Peshawar and Malakand	6.64	26.58	30.56	-	33.22	2.99	-
D.I. Khan	0.07	1.37	4.37	20.18	55.43	13.39	5.19
Rawalpindi	-	-	-	-	-	-	-
Sargodha	16.20	4.01	15.19	3.52	33.92	25.22	1.93
Lahore	2.01	0.47	3.21	38.79	41.60	13.74	0.18
Multan	36.62	0.44	1.39	1.67	39.20	18.88	1.81
Bahawalpur	35.00	-	-	-	35.00	30.00	-
Khairpur	17.34	1.14	6.23	21.52	33.92	8.46	11.40
Hyderabad	40.19	1.17	8.20	-	35.70	9.73	5.01
Quetta	-	-	-	-	-	-	-
Kalat	-	-	-	-	62.50	37.50	-
Karachi	-	-	-	-	-	-	-
WEST PAKISTAN (Weighted Averages)	24.27	1.73	6.77	8.15	37.37	19.29	2.43

TABLE 5.26

CROPPING PATTERN ON FARMS WHERE PRIVATE TUBEWELLS ARE IN ADDITION TO SEASONAL-CANAL IRRIGATION, (1969)
(Based on Survey Data)

Division	Percent of Total Cropped Area						
	Cotton	Maize	Sugarcane	Rice	Wheat	Vegetable and Fodder	Others
Peshawar and Malakand	-	-	-	-	-	-	-
D.I. Khan	-	8.62	13.89	18.05	24.32	23.12	11.99
Rawalpindi	-	-	-	40.32	40.32	19.35	-
Sargodha	21.18	7.55	16.02	0.74	31.86	22.65	-
Lahore	3.21	0.05	2.70	38.13	43.60	11.93	0.37
Multan	38.72	0.02	1.01	1.05	40.57	16.92	1.71
Bahawalpur	38.80	-	-	-	42.14	19.06	-
Khairpur	8.46	2.02	1.98	35.07	26.32	7.22	18.94
Hyderabad	6.47	4.88	0.31	24.36	19.23	29.55	15.20
Quetta	-	-	-	-	-	-	-
Kalat	-	-	-	-	-	-	-
Karachi	-	-	-	-	-	98.04	1.96
WEST PAKISTAN (Weighted Averages)	27.53	0.46	1.75	12.35	39.34	15.28	3.28

TABLE 5.27

DISTRIBUTION OF CROPS ON PRIVATE TUBEWELL-IRRIGATED FARMS, 1969

(Projections Based on Survey Data)

Division	Area (Thousand Acres)						
	Cotton	Maize	Sugar-cane	Rice	Wheat	Vegetable and Fodder	Others
Peshawar and Malakand	0.30	13.34	4.28	-	13.18	3.81	3.81
D.I. Khan	2.71	4.37	3.02	5.30	35.21	7.50	5.91
Rawalpindi	2.35	0.37	7.20	26.37	35.62	19.22	0.75
Sargodha	126.80	22.45	100.67	61.41	331.41	214.00	28.61
Lahore	27.45	6.71	30.06	508.17	561.74	177.46	5.36
Multan	670.27	5.99	26.61	49.31	779.38	272.57	27.05
Bahawalpur	115.19	3.18	22.99	19.70	158.53	68.96	11.13
Khairpur	36.17	4.23	9.36	59.45	74.22	19.51	33.40
Hyderabad	24.43	1.21	4.68	1.50	23.73	7.82	4.33
Quetta	-	-	-	-	26.97	7.96	16.46
Kalat	-	-	-	-	6.35	2.88	1.13
Karachi	-	0.12	-	-	-	56.24	11.88
WEST PAKISTAN	1,005.67	61.96	208.86	731.23	2,046.34	857.92	149.92

without using fertilizers, and fertilizers require more water. Thus the components are ultimately interdependent. The average yields on private tubewell and non-tubewell farms are given in Table 5.28.

TABLE 5.28

YIELD RATES ON PRIVATE TUBEWELL AND NON-TUBEWELL FARMS, 1969 (Projections Based on Survey Data)

Crops	Average Yield (Maunds/Acre)	
	Tubewell Farms	Non-Tubewell Farms
Cotton	11.02	6.4
Sugarcane	372.49	309.0
Rice	21.10	12.3
Maize	15.58	7.0
Wheat	20.75	12.0

Tubewells have also made it possible to use other farm resources more efficiently. Average production costs per unit of land or output tend to be lower on tubewell farms than on non-tubewell farms. The total output of crops on private tubewell-irrigated lands is given in Table 5.29.

As seen from Table 5.29, the total production of crops on tubewell-irrigated lands is: cotton, 2,345 thousand-bales; sugarcane, 2,384 thousand-tons; rice, 541 thousand-tons, and wheat, 1,538 thousand-tons.

The divisions of Sargodha, Lahore, Multan, and Bahawalpur represent the major concentration of privately owned tubewells. The output of crops on tubewell-irrigated farms in these four divisions represent

TABLE 5.29

TOTAL OUTPUT OF CROPS ON PRIVATE TUBEWELL-IRRIGATED LANDS, 1969
(Projections Based on Survey Data)

Division	Gross Yield				
	Cotton (Thousand of Bales)*	Miaze	Sugarcane	Rice	Wheat
		(Thousands of tons)			
Peshawar and Malakand	0.43	7.25	55.40	-	6.97
D.I. Khan	7.50	0.74	5.55	3.50	14.40
Rawalpindi	6.00	0.02	72.40	23.00	27.40
Sargodha	264.60	13.25	1,460.00	48.50	287.60
Lahore	61.20	0.84	216.00	360.00	371.00
Multan	1,529.00	1.65	140.22	41.18	617.46
Bahawalpur	310.70	1.00	214.40	15.29	114.85
Khairpur	89.70	1.62	126.80	47.65	57.76
Hyderabad	76.40	0.36	93.71	1.84	17.17
Quetta	-	-	-	-	19.89
Kalat	-	-	-	-	3.53
Karachi	-	-	-	-	-
WEST PAKISTAN	2,345.53	26.73	2,384.48	540.96	1,538.03

*Bales of 392 lb each.

the major share of the total output from tubewell-irrigated lands. These divisions produced 92 percent of the cotton, 85 percent of the sugarcane, 86 percent of the rice, and 91 percent of the wheat grown on tubewell-irrigated lands in West Pakistan.

On a 100-acre farm, as shown in Table 5.30, a tubewell adds about Rs. 20,000 per year to the gross income of the farmer; an amount two to three times the capital cost of the tubewell. This increase in gross income is sufficient to recover the initial cost of the tubewell in about three years which is less than one third of the useful life of the tubewell.

5.11 Contribution of Private Tubewells to Agricultural Growth

By the end of the second Five-Year Plan period there were about 31,000 tubewells in operation in West Pakistan from which an estimated 8 million acre-feet of water was pumped annually. Of the 26 percent increase achieved in agricultural production in West Pakistan during the second Five-Year Plan, 9 percent was attributed to tubewells.[12]

On an average, gross income per acre-feet of water delivered ranges between Rs. 60 and Rs. 70 per year. On this basis it is estimated that the 42,000 private tubewells installed during the third plan period have added Rs. 1,118 million to the GNP from agriculture during the third plan period, an increase of 12 percent as against 9 percent attributed to them during the second plan.

5.12 Mechanization on Tubewell Farms

Information was also collected to determine the extent of farm mechanization on farms with private tubewells. Table 5.31 shows the

TABLE 5.30

ANNUAL CROP CONTRIBUTION OF PRIVATE TUBEWELLS IN THE III PLAN (FOR A 100-ACRE FARM) 1969
(Based on Survey Data)

Crop	Before Tubewells			Tubewells			Production Difference	Price Per Unit (Rs.)	Value of Difference (Rs.)
	Acres	Yield (Mds/acre)	Production (Mds)	Acres	Yield (Mds/acre)	Production (Mds)			
Cotton	14.5	7.98	115.70	23.0	11.02	253.00	137.30	31.00	4,256
Rice	22.0	15.30	336.60	37.5	21.10	791.00	454.40	20.00	9,080
Sugarcane	4.0	34.00	136.00	4.0	41.00	164.00	28.00	16.50	462
Maize	1.5	8.75	13.00	1.5	15.58	23.00	10.00	13.50	135
*Fodders	8.0	+160.00	o1,280.00	8.0	+200.00	o1,600.00	o320.00	-	320
*Fruits, Vegetables	1.0	65.00	65.00	2.5	75.00	187.50	122.50	11.00	1,348
*Others	3.5	6.00	21.00	2.5	13.03	32.60	11.60	12.00	139
Wheat	32.5	14.30	464.75	27.5	20.75	570.60	105.85	14.00	1,482
Oil Seeds	2.0	5.75	11.50	2.5	16.50	41.25	29.75	23.00	684
Grass	3.0	7.50	22.50	2.0	8.90	17.80	-4.70	-14.40	-68
**Fodders	13.0	+200.00	o2,600.00	14.5	+250.00	o3,625.00	o1,025.00	-	1,025
**Fruits, Vegetables	1.0	65.00	65.00	2.5	75.00	187.50	122.50	11.00	1,348
**Others	1.0	6.00	6.00	1.0	7.50	7.50	1.50	18.00	27
								TOTAL	Rs. 20,238

+ Rs./Acre o Rs. *Kharif Crops ** Rabi Crops

TABLE 5.31

NUMBER OF TRACTORS ON PRIVATE TUBEWELL FARMS, 1969
(Based on Survey Data)

Division	Tractors Owned		Tractors Hired	
	Number	*Percent	Number	*Percent
**Peshawar and Malakand	-	-	-	-
D.I. Khan	11	1.0	-	-
Rawalpindi	32	1.3	48	2.0
Sargodha	2,345	20.4	665	5.8
Lahore	3,192	12.4	2,205	8.6
Multan	3,542	12.2	552	2.0
Bahawalpur	297	6.6	-	-
Khairpur	81	6.1	-	-
Hyderabad	42	8.8	-	-
**Quetta	-	-	-	-
**Kalat	-	-	-	-
**Karachi	24	2.4	-	-
WEST PAKISTAN	***9,566	12.1	3,470	4.4

* Percent of Tubewell-owners
** Data on tractors not available for Peshawar, Malakand, Quetta, Kalat, and Karachi divisions
*** Excluding Peshawar, Malakand, Quetta, Kalat, and Karachi divisions

number of tractors owned on these farms and the number of farms that hired tractors.

As seen from Table 5.31, about 12 percent of tubewell farmers own a tractor and about 4.4 percent of tubewell farmers hire a tractor.

5.13 Number of Tubewells Required for the Fourth Five-Year Plan

The most important factors affecting increases in the agricultural output are fertilizers, improved seeds, plant protection, and irrigation water. For an estimated increase in agricultural output of 5 percent per annum during the fourth Five-Year Plan period, it is estimated that the use of fertilizers, improved seeds, and plant protection would increase the GNP from agriculture about 16 percent. Additional tubewell water will therefore be required to make up the balance of 9 percent to achieve the plan target of a 25 percent increase in the GNP from agriculture.

No significant increase in surface water is foreseen during the fourth plan period, therefore, the entire supply of additional water will have to be provided from underground water resources. The proposed increase in GNP from private and public tubewells will require about 25 MAF of additional water in the next five years. This objective can be achieved by providing a pumping capacity of 8 MAF in the fifth year to irrigate about 2.5 million acres.

If this water is to be provided by private tubewells only, 40,000 of these tubewells with at least 1 cusec average capacity will be required in the next Five-Year Plan and should be installed at the rate of 8,000 to 10,000 every year.

The Salinity Control and Reclamation Project (SCARP) are being implemented by WAPDA. It is expected that about 6,000 public tubewells will be installed under the SCARP program during the Fourth Five-Year Plan. This would give an additional annual pumping capacity of about 6 MAF. Due to the tight financial position it may be expected that this target of 6 MAF additional water from public tubewells may not be achieved. WAPDA in their five year plan has provided for electric connections for 4,000 public tubewells during the next five years. This would mean that the 6,000 public tubewells cannot be brought into operation during the Fourth Five-Year Plan. Instead it is assumed that about 3 MAF additional water will be available from the public tubewells while the balance will have to be provided by private tubewells. The number of private tubewells required to pump 5 MAF is about 30,000 tubewells of 1 cusec capacity. So in addition to the public program 30,000 private tubewells installed at the rate of about 6,000 per year will be required during the Fourth Five-Year Plan.

5.14 Electric Tarrif

Previously 8 paisas per KWH were being charged from tubewell consumers. The recovery of capital cost was not being made except the minimum consumption guarantee. Since WAPDA had to pay high interest rate on the investments the tariff was revised. The quantity of electricity reserved was charged as per killowatt and the quantity consumed at unit rates. The tariff provided for a fixed charge of Rs. 8 per kilowatt of installed capacity and paisas 4 per kilowatt hour for tubewells. Under this tariff tubewell owners with small land holdings who had generally installed motors of bigger capacities had

obviously to pay more for the quantity reserved whereas the consumption was low because of the small land holdings. So the tariff was again changed to Rs. 5 per kilowatt and 6 paisas per kilowatt hour.

At present the Electricity Department of West Pakistan WAPDA requires a 15 percent financial justification on the capital cost excluding the cost of grid supply for extending the 11 K.V. lines. This can be converted to a monthly rental basis of one percent of the capital cost per mensem as is the case for industrial consumers. A subsequent reduction in rent should also be allowed on picking up a new load on the way whether it is a tubewell load or an industrial load. This would mean that the capital return would be in the form of monthly rental and not on the lump sum basis as is the case under the present tariff which is in application since July 1, 1969.

Under the new tariff the tubewell owner has to pay a lump sum share of the capital cost of power facilities out of which first Rs. 7,500/- is born by WAPDA. The remainder amount is to be paid by the consumer. A little benefit is given to the consumer by allowing him to pay the first Rs. 2500/- in five annual interest free installments while the amount in excess to Rs. 2500/- is to be paid in lump sum together with the first installments of Rs. 500/- which causes quite a hardship to the farmers. If the proposal for recovering the capital cost on monthly rental basis is not found feasible then the other alternative may be that the share of capital cost may be recovered in a ten year period with interest against a bank guarantee.

It is expected that these changes if brought about will provide the much needed incentive for the installation of private electric tubewells.

5.15 Performance of Public Tubewells

The West Pakistan Water and Power Development Authority is the main public organization which has installed tubewells in West Pakistan. Of the total 8,519 public tubewells in West Pakistan, 6,304 tubewells have been installed by WAPDA under the program known as "Salinity Control and Reclamation Projects" (SCARPs). The purpose of these tubewells, as given by WAPDA, is to eradicate salinity and waterlogging, and in addition provide water for irrigation.

SCARP-I is their first project and has been operating for eight years. It covers an area of 1.2 million acres in the central portion of Rechna Doab, and consists of 2,058 tubewells, of which 1,796 have been installed by WAPDA and 262 by the Irrigation Department. The project began in 1962 and is managed by the West Pakistan Land and Water Development Board (WPLWDB). The other SCARPs are being implemented and are in partial operation.

The project's progress is reported in annual reports issued by the West Pakistan Land and Water Development Board. All provide detailed information on the status of this project. The information presented below is taken from the annual reports of SCARP-I.

The 2,058 tubewells have an installed capacity of 6,000 cusec and an installed pumping capacity of 3.97 MAF per year. The actual water pumped in 1968-69 was 1.96 MAF which is 54 percent of total capacity. The pumpage by year and the percent of use is given in Table 5.32.

SCARP-I tubewells pumped a maximum of 2.51 MAF in 1963-64. During 1968-69 the pumpage declined to 1.96 MAF. The decline in the pumpage is attributed to several reasons:

1) Temporary stoppage of tubewells due to mechanical or electrical faults. About 13 percent of the tubewells were stopped during 1968-69.

2) Permanent stoppage due to brackish water or damaged bore. Of the 87 tubewells permanently stopped during the 1962-1969 periods, 80 stopped due to brackish water and 7 due to damaged bores.

3) Declining discharges due to corrosion and incrustation of strainers or the water table going below the designed draw-down.

Delivery capacity of the tubewells in SCARP-I decreased by about 22 percent due to corrosion and incrustation of the mild steel strainers.

TABLE 5.32

INSTALLED CAPACITY VERSUS ACTUAL PUMPAGE
OF TUBEWELLS DURING SCARP-I
(From Annual Reports of SCARP-I by WPLWDB)

Year	*Installed Capacity MAF	Pumpage MAF	Use Percent
1961-62	1.21	0.65	52.50
1962-63	3.26	2.27	69.05
1963-64	3.97	2.51	65.21
1964-65	3.91	2.44	59.41
1965-66	3.92	2.49	60.62
1966-67	3.75	1.69	41.52
1967-68	3.64	1.86	49.49
1968-69	3.66	1.96	53.68

*Installed capacity based on 24 hour/365 days usage

The pumping capacity deteriorated from an installed capacity of 6,000 cusec to 4,668 cusec. Table 5.33 shows the decline in delivery capacity of tubewells in various plans of SCARP-I.

A number of public tubewells have been brought back to 78 percent of their designed discharge rate by being rebored, acidized, and blasted or through the addition of another stage of impellers. During 1968-69, 21 tubewells were rebored, 247 tubewells were acidized and blasted, and 28 tubewells had stage impellers added. The discharge capacity would have been much less if these steps were not taken.

The average life of SCARP tubewells was estimated to be 40 years by Tipton and Kalmbach[9] (WAPDA's Consultants), 30 years in the Revelle Report[17] and 20 years by Harza Engineering Company International.[9] But the marked decrease in discharge indicates that these tubewells will not last even for twenty years. The WPLWDB Annual Report of 1964-65 states that approximately 40 percent of the tubewells were deteriorated after three years of operation.

The deterioration included decline in discharge, damaged bores, and the pumping of excessive quantities of sand. In 1964-65 there were 712 tubewells of which 53 tubewells were already seriously deteriorated and 47 tubewells approaching serious deterioration. During this period discharge decline was 6.24 percent which is about a 1 to 2 percent decrease in discharge per year. In 1968-69 the discharge decreased 22 percent which indicates a decrease of 3 to 5 percent per year. If this trend continues, in about six years discharge will be reduced by another 30 percent giving a decline in discharge since 1968-69 of more than 50 percent and it will become uneconomical to pump from these wells. This gives an economic life of the project of about 15 years.

TABLE 5.33

DECLINE IN DISCHARGE OF SCARP-I TUBEWELLS FROM 1962 TO 1969
(From Annual Reports on SCARP-I by WPLWDB)

Name of Scheme	No. of Tube-wells	Installed Capacity (Cusec)	Present Capacity (Cusec)	Decline in Discharge	
				Cusec	Percentage
Pindi Bhattian	21	53.89	31.66	22.22	41.25
Chichokemallian	12	36.00	24.82	11.18	31.06
Chuharkana	24	49.50	38.97	10.53	21.27
Jaranwala	138	353.30	299.80	53.50	15.14
Shahkot	385	1,088.50	853.89	235.11	21.60
Shadman-I	91	259.50	206.33	53.17	20.49
Shadman-II	58	174.00	109.79	64.21	36.90
Zafarwal	393	1,161.50	932.21	229.29	19.74
Hafizabad	320	937.50	587.63	349.87	37.32
Khanqah Dogran	212	647.00	544.25	102.75	15.88
Sangla Hill	233	686.00	582.51	103.49	15.09
Beranwala	126	404.50	336.47	68.03	16.82
Harse Sheikh	44	148.50	120.16	28.34	19.08
SCARP-I	*2,058	5,999.69	4,667.99	1,331.70	22.19

* Includes 1,796 installed by WAPDA and 262 by the Irrigation Department

The average water table depth during 1968-69 was 18 feet 8 inches, while the pre-operation average was 10 feet 8 inches. This is a drop of 8 feet in the water table. The variation of water table depth in SCARP-I is shown in Table 5.34. As seen from Table 5.34 the water table registered a rise during the 1966-67 and 1967-68 periods. This was probably caused by a lesser pumpage during this period as indicated by Table 5.32.

During 1968-69, 1.242 million acres were irrigated giving a cropping intensity of 109 percent. Area irrigated by year is shown in Table 5.35.

The initial target was to achieve a cropping intensity of 150 percent but this has been reduced to 120 percent. After eight years of operation cropping intensity is still below the lowered target value of 120 percent.

Out of 424,717 acres affected by salinity and waterlogging, the area reclaimed at the end of 1968-69 was 261,203 acres or 61 percent of the affected area.

Fiber glass strainers have been used in some SCARP tubewells. Fiber glass is an inert material and it is expected that strainers made from this material will last longer than the mild steel strainers currently used in SCARP-I tubewells. Fiber glass SCARP tubewells have recently been installed and are in operation but no reliable reports on the operation of these tubewells are available. It was observed during the field survey, however, that these modified tubewells are giving a discharge greater than their designed discharge. It is difficult to predict whether this situation will continue because, initially, SCARP-I tubewells with mild steel strainers also pumped more than their designed discharge. Full operation for at least five years will be needed to properly assess the performance of these newer tubewells.

TABLE 5.34

WATER TABLE DEPTH VARIATION IN SCARP-I
(From Annual Reports on SCARP-I by WPLWDB)

Year	Water Table Depth	Increase or Decrease (Over previous year)
1960-61	10 ft - 8 in.	
1961-62	16 ft - 5 in.	- 5 ft - 9 in.
1962-63	17 ft - 5 in.	- 1 ft - 0 in.
1963-64	18 ft - 3 in.	- 0 ft - 10 in.
1964-65	18 ft - 11 in.	- 0 ft - 8 in.
1965-66	19 ft - 9 in.	- 0 ft - 10 in.
1966-67	18 ft - 9 in.	+ 1 ft - 0 in.
1967-68	18 ft - 2 in.	+ 0 ft - 7 in.
1968-69	18 ft - 8 in.	- 0 ft - 6 in.

TABLE 5.35

AREA PLANTED IN SCARP-I
(From Annual Reports on SCARP-I by WPLWDB)

Year	Area Planted (Million Acres)	Intensity Percentage
1959-60	0.850	75
1961-62	0.963	85
1962-63	1.044	92
1963-64	1.124	99
1964-65	1.163	102
1965-66	1.218	107
1966-67	1.153	101
1967-68	1.176	103
1968-69	1.242	109

Therefore, cost comparison of private and public tubewells will be done with data from SCARP-I, from which all relevant data are available.

CHAPTER 6

ECONOMIC ANALYSIS (WEST PAKISTAN)

The field staff was specially trained to obtain the required data from the farmers and tubewell owners. The farmers and tubewell owners may have been apprehensive that the survey would lead to an increase of taxes on their property and income, and therefore, may have been hesitant to provide correct information. In addition, the farmers did not usually keep an accurate record of initial and recurring expenditures of either their tubewells or their farming. The field staff, therefore, had to use their judgment to insure the information was as correct as possible.

A comparative economic analysis of private tubewells versus public tubewells was made from the data available from the districts of Sialkot, Gujrat, Gujranwala, Sahiwal, and Multan. These districts have a high concentration of private tubewells.

6.1 Cost of Installation of Private Tubewells

Tubewell installation costs include the cost of the pit, bore, blind pipe, strainer, and motor and pump.

The farmers surveyed generally use centrifugal pumps for their tubewells because the initial cost of such pumps is low, and the pumps are easy to maintain. However, centrifugal pumps have a limited suction head and must be installed at the bottom of pits to keep the suction head within allowable limits.

The pits are generally circular and their depth is variable depending on location. A bore is drilled from the bottom of the pit to the ground water aquifer and a blind pipe and strainer is installed.

The blind pipe is usually manufactured from mild steel sheets or from galvanized iron. The strainer, a slotted pipe which will allow ground water to seep into it while preventing passage of soil particles, is fitted to the aquifer-end of the blind pipe. The coir string type of strainer is generally used in private tubewells.

Table 6.1 gives the sizes of various tubewell components and how they vary among major tubewell districts of West Pakistan.

TABLE 6.1

TUBEWELL COMPONENTS AND THEIR DIMENSIONS, 1969
(Based on Survey Data)

District	Pit Depth Average ft	Blind Pipe Length ft	Blind Pipe Dia in.	Strainer Length ft	Strainer Dia in.	Delivery Pipe Length ft	Delivery Pipe Dia in.	Motor Capacity Average, hp	Engine Capacity Average, hp
Sialkot	4.0	35.0	6	44	6	5.5	5	15	18
Gujrat	13.8	38.0	5	30	6	19.5	4	15	19
Gujranwala	3.0	36.5	6	71	6	3.2	5	17	17
Sahiwal	16.0	23.5	5	80	6	20.0	4	17	21
Multan	18.0	26.0	6	102	6	27.0	6	20	20

The variations in the depth of the ground water table are indicated by the changes in the depth of the pit, which ranges from about 3 feet in Gujranwala to about 18 feet in Multan. Similarly, the depth of bore ranges from 68 feet at Gujrat to 128 feet at Multan.

The cost of a tubewell depends upon the size of its components. The size of tubewell components depend on discharge and suction and delivery heads which in turn depend on the depth of the water table. Thus in Multan,

where the ground water is found at a lower depth, the cost of a tubewell is higher than other places.

The cost of installation of a tubewell also depends on its power source. If all the components of a tubewell and the capacity of the engine or motor are the same, the cost of installation of an electrically powered tubewell will be less than a diesel-powered tubewell.

Table 6.2 gives the average installation cost in rupees for a one-cusec capacity tubewell in five major districts of West Pakistan.

TABLE 6.2

AVERAGE INSTALLATION COST OF A ONE-CUSEC CAPACITY PRIVATE TUBEWELL, 1969
(Based on Survey Data)

Item	Installation Cost (Rs)					
	Sialkot	Gujrat	Gujranwala (District)	Sahiwal	Multan	Average
Electric Motor Control and Pump	3,600	3,132	3,264	3,687	4,217	3,619
Diesel Engine Accessories and Pump	5,420	5,785	4,971	6,487	6,247	5,874
*Materials and Labor	2,310	2,332	1,626	2,862	5,690	3,229
Total Cost:						
Electric Tubewell	5,910	5,464	4,890	6,549	9,907	6,848
Diesel Tubewell	7,730	8,117	6,597	9,349	11,937	9,103

*Includes costs for pipes, strainer, drilling, and miscellaneous items.

The average installation cost of an electrically powered tubewell in the four doabs of the Punjab is about Rs. 6,848. The cost varies from about Rs. 4,900 in Gujranwala to about Rs. 9,900 in the Multan district.

Similarly, the average installation cost per diesel tubewell in the four doabs of Punjab is about Rs. 9,103. The cost varies from about Rs. 6,600 in Gujranwala to about Rs. 12,000 in the Multan district.

As previously mentioned the difference in the cost of installation of tubewells in different districts is mainly due to the depth of the water table. The availability of tubewell components is also a factor because prices of these items vary from district to district.

6.2 The Annual Operating Cost of Private Tubewells

The annual total operating cost of a private tubewell includes: a) operating cost, b) replacement and repair cost, and c) amortization-of-capital cost.

a Operating cost

The operating cost of private tubewells, as reported by the farmers, was not considered to be a reasonable figure. Therefore, an alternative method of ascertaining this cost was used; an estimate was made from the horsepower of the engine or motor and the hours of operation of the tubewell.

During the survey it was observed that the engines/motors installed on private tubewells were generally of greater capacity than necessary. This, consequently, results in an uneconomical operation of the tubewell. For example, tubewells of 1 cusec capacity working against a head of about 30 feet and motors/engines of 15 to 20 hp, whereas a 5 hp unit would have been sufficient. Table 6.3 gives the average horsepower

ratings of the engines/motors of private tubewells (at 75 percent efficiency) in some important districts in West Pakistan.

The electricity or fuel consumed in the operation of a tubewell depends upon the actual discharge and the total head the water is lifted; it has no direct relation to designed horsepower of the motor/engine. The designed horsepower would tend to limit some maximum values of discharge and total head for the tubewell, according to the relation located at the bottom of Table 6.3.

TABLE 6.3

ENGINE/MOTOR HORSEPOWERS FOR PRIVATE TUBEWELLS, 1969
(Based on Survey Data)

District	Discharge cusec	Average Head ft	Horsepower		
			Theoretical Requirement	Provided Motor	Provided Engine
Sialkot	1.00	30	5	15	18
Gujrat	0.75	40	5	15	19
Gujranwala	1.00	25	4	17	17
Sahiwal	1.10	45	7	17	21
Multan	1.10	50	8	20	20

$$\text{Horsepower} = \frac{\text{Discharge in lb/sec} \times \text{Total Head in ft}}{550 \times \text{Efficiency of the Unit}}$$

The fact emphasized earlier, that the power actually consumed in the operation of tubewells is generally less than the installed capacity, is shown in Table 6.4 obtained from public as well as private electric and diesel tubewells.

TABLE 6.4

COMPARATIVE FUEL COSTS FOR PUBLIC AND PRIVATE TUBEWELLS

Type of Tubewell	Operational Cost Per Year Based on the Installed Capacity of Motor/Engine	Operational Cost Per Year Based on the Actual Expenditure
SCARP-I public tubewell	Rs. 9,000.00	Rs. 5,850.00
*Electrically operated private tubewell	Rs. 2,200.00	Rs. 2,125.00
*Diesel-operated private tubewell	Rs. 3,080.00	Rs. 2,600.00

*Based on actual costs reported by farmers.

The actual cost of electricity consumed by a public tubewell was found to be 65 percent of that based on the installed capacity. For power cost of electrically operated and diesel-operated private tubewells these figures are 97 percent and 84 percent, respectively.

It was generally observed during the field survey that the tubewell owners were very reluctant to reveal information about their various expenditures. From personal experience it appeared that they tended to give higher than actual figures for their expenditures and lower than actual figures for their income. The high percentages of 97 and 84 for private tubewells as compared to 65 for public tubewells is believed to be the result of this psychological attitude of the farmers.

To compare the cost of public with private tubewells it was, therefore, necessary to devise a method to ascertain the correct actual expenditure for private tubewells. One approach taken was to use the expenditure incurred in a public tubewell for electricity as the basis, as this was considered to be the more correct and dependable figure. The adjusted

actual operational cost for private electric and diesel tubewells, then becomes 65 percent of Rs. 2,200 and Rs. 3,080, respectively, or Rs. 1,430 for private electrically powered tubewells and Rs. 2,000 for private diesel-powered tubewells. The adjusted figures are shown in Table 6.5.

b. Replacement and repair cost

Tubewell owners were able to provide a detailed breakdown of annual replacement and repair costs only after much help was given by the field staff. The information supplied by farmers was then evaluated and adjusted to make it more realistic. The cost of annual repair and replacement costs are summarized in Table 6.6.

c. Amortization of capital cost

Sound investment requires that capital invested in a tubewell be returned (with interest) to the investing party within the useful life of the tubewell. This is usually done by depositing annual installments in a so-called "sinking fund" drawing compound interest at a given rate, here assumed to be 8 percent. These installments, together with the interest, would therefore be equal to the capital cost at the end of the amortization period.

The period of amortization depends on the useful life of the tubewell which, in turn, depends on the useful life of certain critical tubewell components. A well constructed and well maintained electric motor or diesel engine and pump may be assumed to have an effective economic life of 20 years, however, the coir string strainer used most commonly in private tubewells is estimated to have an economic life of 12 years. In about 12 years the strainer is blocked and the tubewell discharge is reduced to uneconomical rates. The economic life of a private tubewell is, therefore, estimated to be 12 years. The sinking fund factor at 8

TABLE 6.5

ADJUSTED ANNUAL COST OF OPERATION OF PRIVATE TUBEWELLS, 1969
(Based on Survey Data and SCARP-I Data)

Type of Tubewell	Cost of Operation					Weighted Average
	Sialkot	Gujrat	Gujranwala (District)	Sahiwal	Multan	
Electric Tubewell						
Cost of Electricity	1,080	1,010	1,120	1,580	1,900	1,430
Total hours of operation	1,740	1,670	1,700	2,400	2,450	2,130
Diesel Tubewell						
Fuel	1,530	1,550	1,410	2,340	2,390	2,000
Lubrication	460	440	450	505	530	491
Operator's pay*	430	410	460	480	470	461
Total Cost:	2,420	2,400	2,320	3,325	3,290	2,952
Total hours of operation:	1,740	1,670	1,700	2,400	2,450	2,130

* The operator is generally part time.

TABLE 6.6

ANNUAL REPAIR AND REPLACEMENT COSTS OF PRIVATE TUBEWELLS, 1969
(Based on Survey Data)

Component	Information Supplied by the Farmers	Annual Cost Rs.
Pit	Pit is dug and maintained by family labor.	
Bore	On the average, Rs. 1,000 are spent after about every five years to re-drill the bore of the tubewell.	200
Engine (Diesel)	An average of Rs. 2,000 are spent after every five years for the repair of diesel engines.	400
Motor (Electric)	On an average, Rs. 500 are spent about every five years to rewind and repair the electric motors and starters.	100
Pump	Rs. 100 are spent after every four years for the repair of pumps.	25
Miscellaneous items	Rs. 50 per year	50
		Average annual cost of repair
Electric Tubewell		375
Diesel Tubewell		675

percent interest for a 12 year period of amortization is 0.052695. Based on installation costs of Rs. 6,848 for electrically powered tubewells and Rs. 9,103 for diesel powered tubewells, the annual amortization costs are Rs. 359 and Rs. 480, respectively.

The annual costs for private tubewells are summarized in Table 6.7. The annual capital cost is added to the annual operation and maintenance costs to give the total annual costs. The total annual cost divided by the amount of water pumped during a year gives the cost of one acre-foot of water.

TABLE 6.7

SUMMARY OF ANNUAL COSTS FOR PRIVATE TUBEWELLS, 1969
(Based on Survey Data)

Item	Electric Tubewell (Rs.)	Diesel Tubewell (Rs.)
Operation Cost	1,430	2,952
Replacement and Repair	375	675
Amortization-of-Capital Cost	359	480
Total Annual Cost	2,164	4,107
Capacity of Tubewell	1.1 cusec	1.1 cusec
Annual Working Hours	2,130	2,130
Water Pumped Annually	195 AF	195 AF
Cost/Acre-foot	Rs. 11	Rs. 21

The total annual cost for an electric tubewell is Rs. 2,164 while that for a diesel tubewell is Rs. 4,107. The water pumped annually by a tubewell of 1.1 cusec capacity and operating for 2,130 hours per year

has been calculated to be 195 acre-feet. The cost of water is Rs. 11/AF for an electric tubewell and Rs. 21/AF for a diesel tubewell. Therefore, a private electric tubewell is cheaper than a private diesel tubewell.

6.3 Installation and Operating Costs of Public Tubewells

a. Installation cost

The Water and Power Development Authority installed 1,796* tubewells in SCARP-I at a total cost of Rs. 95.8** million. This amount does not include the cost of electric transmission and distribution facilities which were provided by WAPDA to operate the tubewells. The cost of power provision for the tubewells in SCARP-I was Rs. 57.6 million. The average cost of a tubewell without power facilities and the average cost for providing power facilities per tubewell is Rs. 53,340 and Rs. 32,100, respectively. The total average cost of WAPDA installed public tubewells (1,796) in SCARP-I is thus Rs. 85,440.

b. Operating cost

The annual cost incurred in the operation and maintenance of a public electric tubewell also includes the cost of electricity and the salaries of the staff. These costs are added to the component maintenance costs which include the reboring, treatment, and addition of impellers.

The total operation cost for SCARP-I tubewells in 1968-69 as reported by WPLWDB is Rs. 20,188,512***. The costs included are electricity,

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*The figure from the completion report of SCARP-I is Rs. 94.15 million but it is indicated in the completion report that this is not the final figure. This figure has been obtained from Mr. Sayyed Hamid, Retired Chief Engineer WAPDA.

**The 262 tubewells installed in SCARP-I by the Irrigation Department are not included in the calculations.

***This figure is based on operation of 2,058 tubewells now managed by WPLWDB (1,796 installed by WAPDA and 262 installed by the Irrigation Department).

administrative charges, tubewell maintenance and repairs, salaries of the WPLWDB staff* and the expense of agricultural and cooperative wings. Table 6.8 gives a summary of these costs for SCARP-I.

The agricultural and cooperative wings provide extension services to the farmers and their expenses have no direct bearings on the cost of water delivered by tubewells. Therefore the expenditure on these two wings Rs. 1,364,247 is substracted from the total cost of operation of SCARP-I. The adjusted total cost of operation of 2,058 tubewells in SCARP-I then becomes Rs. 18,824,265 which gives the average cost of operation per tubewell of Rs. 9,147 per year for the 1968-69 period.

TABLE 6.8

OPERATING COSTS FOR SCARP-I, 1968-69

As reported by the Directorate of SCARP-I, West Pakistan Land and Water Development Board, Lahore, in the Annual Report for SCARP-I for 1968-69.

Item	Cost (Rs.)
Electricity	10,472,322
Running and Repair of Vehicles	199,739
Maintenance and Repair of Tubewells	3,025,440
Work Charged to Establishment	2,161,831
Distribution Divisions	2,055,212
Stores and Workshop Division	309,024
Agriculture Wing	1,103,923
Cooperative Wing	260,324
Directorate Office	600,697
Total Operation Cost	20,188,512

*Foreman, electricians, fitters, tubewell operators, cycle messengers, masons and field storekeepers.

c. Amortization-of-capital cost

An explanation of amortization-of-capital and the criteria used to estimate the economic life of the existing types of tubewells in Pakistan can be found in Chapter 6, Section 6.2(c). The Harza Engineering Company estimate of a 20-year economic life for a SCARP-I tubewell is re-evaluated to be 12 years for reasons cited in Chapter 6.

The amortization factor of 8 percent for a 12-year economic life is 0.1327. The average capital cost for a SCARP-I tubewell is Rs. 53,340 without power facilities which gives an annual capital cost of Rs. 7,078.

Economic life for power facilities is estimated to be 30 years. The amortization factor of 8 percent for a 30-year economic life is 0.088827. The average cost of installation for power facilities is Rs. 32,100 which gives an annual capital cost of Rs. 2,851. The total annual capital cost of one tubewell, therefore, is Rs. 9,929 including power facilities. The annual costs of SCARP-I tubewells are summarized in Table 6.9.

TABLE 6.9

SUMMARY OF ANNUAL COSTS FOR PUBLIC TUBEWELLS SCARP-I
(From Annual Report of SCARP-I by WPWLPB)

Operation and Maintenance	Rs. 9,147
Amortization Cost	
Without Power Facilities	Rs. 7,078
With Power Facilities	Rs. 9,929
Total Annual Costs	
Without Power Facilities	Rs. 16,225
With Power Facilities	Rs. 19,076
Water Pumped	1.96 MAF
Number of Tubewells	2,058
Average Water Pumped per Tubewell	952 AF
Cost of Water	
Without Power Facilities	Rs. 17/AF
With Power Facilities	Rs. 25/AF

CHAPTER 7

DISCUSSION OF RESULTS

7.1 Installation of Private Tubewells

At the end of 1969 there were a total of 89,050 tubewells in Pakistan; 87,752 in West Pakistan and 1,298 in East Pakistan. Of the 87,752 tubewells in West Pakistan, 79,233 were privately owned. Of the 1,298 tubewells in East Pakistan, only 12 are privately owned (located in the Sylhet Tea Gardens).

Sixty-one percent (48,520) of the private tubewells in West Pakistan are operated by diesel engines and thirty-nine percent (30,713) are operated by electricity.

The 79,233 private tubewells in West Pakistan represent an investment of about Rs. 689 million made by the farmers. This amount includes a credit of about Rs. 124 million from official agencies which is 18 percent of the total investment. This credit is to be returned by the farmers with 8 percent interest.

In West Pakistan the major concentrations of private tubewells are in the divisions of Sargodha, Lahore, Multan, and the district of Gujrat. These areas have 71,815 private tubewells or 90 percent of the total private tubewells in West Pakistan. The Multan Division has the maximum number of private tubewells (28,167 or 35.6 percent of the total private tubewells in the province); next is the division of Lahore (25,617 or 32.6 percent of the private tubewells in the province). Among the districts, Sahiwal has the maximum number of private tubewells (13,469 or 17 percent of the total). The Hyderabad and Kalat divisions have the minimum number of tubewells in West Pakistan.

In Multan Division about 74 percent of the private tubewells were installed by farmers having more than 25 acres of land while in Lahore this percentage is 49. In Sargodha the corresponding percentage is 64.

The figures quoted above show that the land holdings of tubewell owners in Multan are generally bigger than in Sargodha and Lahore. Multan Division is the main cotton and wheat producing area of West Pakistan and the irrigation water requirements are high in both Rabi and Kharif seasons. These factors, coupled with the shortage of surface water, have resulted in the installation of the largest number of private tubewells in this division. Moreover, Multan Division has the largest cultivable area of all the divisions of the Indus Plain.

In Lahore Division the main crops are rice and wheat. Rice requires a large amount of irrigation water. The water table in Lahore Division is generally close to the surface and consequently about 64 percent of the tubewells are less than 100 feet deep. The closeness of the water table results in a comparatively low cost of installation. These factors have resulted in the installation of a large number of tubewells in the Lahore division even though the amount of annual precipitation is higher in Lahore than in most other parts of the Indus Plain.

In Sargodha Division the land is quite fertile and suitable for wheat and cotton. The ground water in some parts of Sargodha, Jhang, and Lyallpur districts is of a poorer quality than that in Multan and Lahore. Several plans of salinity control and reclamation are in operation in Sargodha Division. In areas of poor quality ground water, where SCARPs are being implemented, there are official restrictions on the installation of private tubewells and consequently the rate of installation of private tubewells has been decreasing in the Sargodha Division since 1967.

In divisions of Quetta, Kalat, and Karachi ground water is not easily available. Moreover, water in the Karachi division is of poor quality. There is no continuous recharge to the ground water aquifer in those divisions and therefore sustained supply from tubewells cannot be obtained. In the Quetta, Kalat, and Karachi divisions the water table is deep resulting in a high cost of installation. Also, the water table in these divisions is continually falling and this requires a deepening of the tubewells almost every year which results in higher operation and maintenance costs. Water cannot be pumped continuously for more than two or three hours in these divisions; pumping has to be stopped so that the well may be recharged.

Peshawar, Malakand, and parts of Rawalpindi divisions (with the exception of Gujrat District) are hilly areas and there is not enough water available except in the district of Mardan. Thus, there are less tubewells in these areas than in Sargodha, Lahore, and Multan.

Various factors affecting the installation of private tubewells are: size of holdings, average annual precipitation, availability of good quality ground water at moderate depths, quality of land, financial resources, and the progressiveness of the farmers.

The rate of installation of private tubewells has declined during the last three years. Although it is difficult to pinpoint the causes of decline, the decline may have been a result of the abundance of canal water supplies due to the completion of the Link canals and Mangla Dam, and that most parts of Chaj Doab, Thal Doab, Rechna Doab, and Bari Doab have been covered by SCARPs. These factors, coupled with the ban on new electric connections for tubewells and the new electric tariff, may have been responsible for the decline in installation of private tubewells.

In East Pakistan the land holdings are very small in comparison to those in West Pakistan. Individual land owners do not generally have the financial resources and enough cultivable area to justify installing a private tubewell. Moreover, the small holdings of a farmer are usually scattered. There is also a problem of water conveyance because of the absence of field channels. The field channels can be constructed only when the holdings have been consolidated and this had not been done as yet. These factors have been responsible for the near nonexistence of private tubewells in East Pakistan.

7.2 Ground Water Pumped

The average operational period of a private tubewell has been estimated to be 2,130 hours per year. This low utility rate is because of sporadic irrigation requirements and pump stoppages. Water is not required all the time because of the limited size of holdings, rainfall, and crop conditions; periods of forced closures are due to lack of electricity or fuel. The use of private tubewells is higher in bigger holding sizes. The average hours of operation vary from 1,491 for holdings of less than 10 acres to 3,500 for holdings of 200 acres or more. Average hours of operation increase when tubewell owners sell water to their neighboring farmers.

In West Pakistan private tubewells pumped over 14 MAF of water during 1969, at an estimated cost of about Rs. 250 million. The tubewells in the Sargodha, Multan, and Lahore divisions accounted for about 12.4 MAF of the 14 MAF during this period. The 4,147 WAPDA tubewells in operation in West Pakistan pumped about 5 MAF during 1969. The pumpage from other public tubewells is estimated to be about 1 MAF. This gives a total pumpage from

the ground water reservoir of about 20 MAF. Ground water that can be pumped every year from under the canal-irrigated areas of the Indus Plain is estimated to be 42 MAF under ideal conditions. At this time (1970) pumpage of about 20 MAF per year has had no negative effect on the ground water table in West Pakistan. Although the estimated recharge of 42 MAF per year has not yet been reached, there is still a substantial potential for ground water development in West Pakistan. It appears that tubewell development can take place unrestricted for the next 5 to 10 years. The ground water recharge should be continually assessed and compared with the ground water pumpage to formulate further policies and development plans.

In East Pakistan 0.217 MAF of water was pumped during 1969 by the 802 tubewells in operation. The tubewells in Dinajpur district pumped 0.128 MAF during the same period.

7.3 Cost of Installation of Private Tubewells

Although the rate of installation of private tubewells is declining their number is ever increasing. Their cost of installation ranges from about Rs. 6,000 to Rs. 9,000 for electric tubewells and from Rs. 9,000 to Rs. 13,000 for diesel tubewells. These figures pertain to the major areas of tubewell concentration. Private tubewells are profitable to their owners and are completely amortized in about two to three years.

Even the present low cost of installation of a private tubewell is not within the reach of all farmers. About 60 percent of the private tubewells have been installed by those farmers who own more than 25 acres. Farmers with small holdings have been generally reluctant to install

tubewells because their small holdings are generally scattered and cannot be effectively irrigated by one tubewell.

7.4 Cost Comparison of Private and Public Tubewells

The cost comparison of private and public tubewells has been computed on the basis of the cost of water pumped. The cost of water pumped from a private electric tubewell is estimated to be Rs. 11 per acre-foot while that for a private diesel tubewell is Rs. 21. The cost of water from a public electric tubewell is estimated to be Rs. 17 per acre-foot without considering power facilities, and Rs. 20 per acre-foot when considering power facilities.

It is evident therefore that a private electrically operated tubewell is cheaper than a private diesel-operated tubewell or a public tubewell. The private diesel tubewell, however, has a higher cost per acre-foot of water pumped than a public tubewell.

Private tubewells have the following advantages over public tubewells:

1. The foreign exchange requirement for a private tubewell is small but very high for public tubewells. Moreover, public tubewells have to be financed mainly from foreign loans which have to be repaid in foreign exchange.
2. Private tubewells help in the development of local industry with items such as diesel engines, drilling rigs, pipes, and strainers. On the other hand, the public tubewells discourage the development of these industries as most of the material is imported from foreign countries.

3. Private tubewells are no financial burden on the government except for power transmission facilities and even then only 40 percent of the private tubewells run on electricity.

Private diesel tubewells are estimated to consume diesel oil worth Rs. 150 million per year which amounts to about Rs. 100 million in foreign exchange every year. The burden on foreign exchange resources can be reduced if electricity is provided for more private tubewells.

As shown from the above discussion, a private electric tubewell is cheaper in terms of water pumped. The private diesel tubewell has a higher cost per acre-foot of water pumped than a public tubewell but like private electric tubewells has the added advantage of helping in the development of local industry and reducing the burden on the government.

7.5 Contribution of Private Tubewells to Agriculture

Cropping intensities on tubewell farms have been found to be about 30 to 40 percent higher than on nontubewell farms. This indicates that tubewells make it possible to crop most of the land twice or more in one year. It is estimated that a tubewell of one cusec capacity on a 60-acre farm adds 25 to 30 acres to the cropped area and this factor alone would increase farm income 40 to 50 percent more than that possible on a similar nontubewell farm.

An average tubewell of 1 cusec capacity adds about Rs. 200/acre/year to the gross income of the farmer. Net income attributable to tubewells ranges from Rs. 60 to Rs. 70/acre/year. On this basis it has been estimated that during the third Five-Year Plan private tubewells could add about Rs. 1,118 million to the Gross National Product from agriculture;

an increase of 12.05 percent as against the 9 percent which was attributed to them during the second plan.

CHAPTER 8

CONCLUSIONS

1. At the end of 1969 there were 89,050 tubewells in Pakistan.

2. In West Pakistan there are 87,752 tubewells. The number of private tubewells is 79,233 while the number of public tubewells is 8,519.

3. In East Pakistan there are 1,298 tubewells. The number of private tubewells is 12 and the number of public tubewells is 1,286. The number of tubewells in operation at the end of 1969 were 862.

4. In West Pakistan 48,520 of the private tubewells or 61 percent are operated by diesel engines while 30,713 or 39 percent tubewells are run by electric motors.

5. Private tubewells in West Pakistan represent an investment of Rs. 689 millions. Credit from official agencies was used for 16 percent of the private tubewells. Credit of Rs. 124 million is to be returned at 8 percent interest. The cost of operation of private tubewells is about Rs. 250 million and is financed by the private sector.

6. In West Pakistan, the major areas of concentration of private tubewells are the divisions of Sarghoda, Lahore, Multan and the district of Gujrat. About 90 percent of the private tubewells have been installed in these areas.

7. The divisions of Hyderabad, Kalat, Quetta and Karachi have only 3.9 percent of the total private tubewells.

8. The factors affecting the installation of private tubewells are; the size of holdings, compactness of holdings, availability of good quality ground water at moderate depths, quality of land, financial resources, and progressiveness of the farmers.

9. In West Pakistan 61 percent of the private tubewells are owned by farmers holding more than 25 acres of land while about 28 percent of the tubewells are installed by farmers holding 11 to 25 acres of land and about 11 percent of the tubewells are owned by farmers holding less than 10 acres.

10. The average period of operation of private tubewells in West Pakistan is 2,130 hours per year. The period of operation depends, in addition to the size of holding owned by the tubewell owners, on the availability of canal water and rains, possibilities for sale of water, fertilizer, use and availability of farm equipment, and labor. The period of operation increases from 1,491 hours per year for holding of less than 10 acres to 3,500 hours per year for holdings of 200 acres or more.

11. The average delivery capacity of a private tubewell is about 1 cusec. About 48 percent of the private tubewells have delivery capacity of less than one cusec while about 52 percent of the tubewells have delivery capacity of more than 2 cusec. The combined delivery capacity of private tubewells is 82,179 cusec.

12. In West Pakistan private tubewells are estimated to have pumped over 14 MAF of water during 1969. During the same period approximately 6,000 public tubewells in operation pumped over 6 MAF of

water. The 802 private and public tubewells in operation in East Pakistan pumped about 0.25 MAF in the same year.

13. In West Pakistan the cost of installation of private tubewells varies between Rs. 6,000 and Rs. 9,000 for electric tubewells and between Rs. 9,000 to Rs. 13,000 for diesel tubewells.

14. The average cost of operation in areas of concentrated use of tubewells varies between Rs. 1,600 and Rs. 3,000 for electric tubewells and between Rs. 3,000 and Rs. 4,800 for diesel tubewells.

15. The cost per acre-foot of water pumped is Rs. 11 for private electric tubewells and Rs. 21 for private diesel tubewells. The cost of water from public tubewells of SCARP-I is Rs. 17 per acre-foot without considering the cost of power facilities and Rs. 20 per acre-foot when considering the cost of power facilities.

16. About 42 percent of private tubewells are installed on canal-irrigated lands. Of the 33,236 tubewells installed on canal-irrigated lands 13,027 tubewells have been installed on farms irrigated by seasonal canals while 20,210 tubewells have been installed on farms irrigated by perennial canals.

17. Private electric tubewells are cheaper than private diesel or public electric tubewells in terms of the capital and operational costs per unit of water pumped. The foreign exchange requirement for private tubewells are low compared to those for the public tubewells.

18. Tubewells stimulate development of local industry in pipes, pumps, motors, engines, and strainers and provide employment opportunities for the people. In case of private tubewells the government is not financially burdened.

19. The coir string type of strainer is used in most of the private tubewells. About 84 percent of the private tubewells have coir string strainers, about 6 percent of the private tubewells use brass strainers and about 9 percent of the private tubewells have been developed on open wells.

20. Sixty percent of the private tubewells use blind pipe of 6-inch diameter. About 13 percent of the tubewells use blind pipes of more than 6-inch diameter, the rest use pipes of less than 6-inch diameter.

21. Almost 96 percent of the private tubewells have a bore depth less than 200 feet. About 44 percent of the tubewells have a bore depth less than 100 feet.

22. About 46 percent of the private tubewells have a motor or engine capacity ranging from 15 to 20 horsepower. About 17 percent of the private tubewells have a motor or engine capacity of more than 20 horsepower.

23. Private tubewells irrigated an area of about 5 million acres in 1969 giving an overall cropping intensity of about 121 percent. Cropping intensity varies from 81 percent to 151 percent. The area irrigated by the tubewells included about 2.5 million acres of canal-irrigated areas.

24. The production of various crops in 5 million acres where tubewells have been installed are:
Cotton 2,343,000 bales, rice 541,000 tons, and wheat 1,533,000 tons, and yields are still increasing as greater inputs of water are made available from tubewells.

25. It is possible to obtain higher cropping intensities (150 percent or more) because adequate water application is possible on tubewell farms. It is in contrast to a 100 percent or less cropping intensity on non-tubewell farms which generally are deficient in water application.

26. Tubewells help stimulate the use of improved inputs like fertilizers, improved seeds and plant protection thus laying a sound basis for commercial agriculture.

27. Additional water from tubewells may increase gross income about Rs. 200 per acre. It is estimated that during the third Five-Year Plan, tubewells added 12 percent to the GNP from agriculture.

28. There seems to be no major duplication of efforts in the private and public sector in the installation of tubewells. Farmers install tubewells in areas where canal water is either not available or scarce, land and ground water quality is good and an immediate return is expected. There has been very little growth of private tubewells in areas where good quality water is not available or the land is affected by waterlogging or salinity on a large scale. It is in these areas that the government has provided tubewells for reclamation.

29. The rate of installation of private tubewells has been declining since 1966. Special efforts will be needed to maintain growth of private tubewells.

CHAPTER 9

RECOMMENDATIONS

The following policies and action plans are recommended in connection with the private and public tubewells.

9.1 East Pakistan

1. The low lift pumps have the lowest capital cost and the lowest annual running cost. It is recommended that the program of installing low lift pumps should be enlarged. Tubewells should be installed only in those areas where low lift pumps cannot be installed. It is recommended that 26,000 low lift pumps of one to two cusec capacity and 10,000 small capacity tubewells be installed during the fourth Five-Year Plan.

2. The financial resources of a typical farmer in East Pakistan are meager and he may not be able to finance installation of tubewell or lift pump on his own. Due to the existing plans for public tubewells the private program is not likely to flourish unless liberal, financial help and credit facilities, at easy terms, are provided.

3. The land holdings are generally too small to justify installation of a private tubewell by an individual farmer. In order to avoid over capitalization, cooperative societies for using ground water should be encouraged, as has been done by the Pakistan Academy for Rural Development in Comilla.

4. Besides establishment of cooperative societies as suggested in (3) above consolidation of holdings would go a long way in

developing an efficient use of water. In East Pakistan the holdings are extensively fragmented and scattered. Effective government machinery is required to do the job in the shortest possible time.

5. It was observed that technical facilities for installing tubewells in the private sector are quite meager, and are mostly owned and operated by the government. In order to accelerate development of private tubewells special efforts will be needed. In addition to financial help and the consolidation of holdings, efforts should be made so that electric motors, diesel engines, pumps, strainers and pipes etc. are available at moderate prices.

6. Before embarking upon a program of tubewell installation it is necessary that an inventory of ground water resources in East Pakistan is made. Coordination between EPADC and EPWAPDA for ground water survey is essential to avoid duplication of efforts.

9.2 West Pakistan

1. Private tubewells being economically sound, it is recommended that installation of private tubewells should be encouraged.

2. The private tubewells are installed by the farmers for irrigation purposes. Private tubewells do not prosper in saline and waterlogged areas and in areas of poor quality ground water. There seems to be no duplication of efforts in the installation of private and public tubewells. It is, therefore, recommended that in the future new government projects should be undertaken in

saline and waterlogged areas and areas of poor quality ground water. Fresh water areas and areas not affected by salinity and waterlogging should be left for private development.

3. For an estimated increase in agricultural production of 5 percent per annum during the fourth plan period, it is recommended that 30,000 tubewells of average capacity of 1 cusec should be installed in the private sector at the rate of about 6,000 tubewells per year in addition to the public sector tubewells. If all the additional water is to be provided from private tubewells then 40,000 tubewells of average capacity of one cusec should be installed at the rate of 8,000 to 10,000 tubewells per year.

4. Electric tubewells are cheaper than diesel tubewells. Electric tubewells, in addition to having lower capital and running costs, are easier to operate. Farmers, therefore, generally prefer installation of an electric tubewell if electricity is easily available. Power connections for agricultural tubewells should be made easily available.

   Extension of electricity transmission lines to the areas of diesel tubewell concentration should be taken up during the fourth-Five Year Plan. These areas include the districts of Sahiwal, Multan, Sialkot, Gujranwala and D.I. Khan where diesel tubewells are concentrated.

5. Electric tubewells besides being cheaper in terms of water pumped, have less burden on the foreign exchange resources of the country, in comparison to diesel tubewells. It is estimated that for

existing tubewells the diesel oil imported from foreign countries involves about Rs. 150 million every year in foreign exchange. If electricity is liberally provided for private tubewells, the burden on foreign exchange resources will be reduced.

6. Water & Power Development Authority has planned that during the next five years, electric connections will be provided for 17,000 tubewells of which 4,000 will be public tubewells. Thus 13,000 electric connections will be provided for private tubewells in the next five years. If as it is recommended here, 30,000 private tubewells are installed during the fourth - Five Year Plan then 17,000 diesel tubewells will be required. These tubewells will consume diesel oil worth about Rs. 50 million every year. It is recommended that electric power should be provided for a larger percentage of private tubewells to reduce the annual expenditure in foreign exchange.

7. The new electricity tariff introduced by WAPDA is based in part on the installed capacity of the tubewells. This tariff has benefited tubewell owners with holdings of about 50 acres or more who use a higher percentage of tubewell capacity, but tubewell owners with small holdings have to pay more per hour of operation. The present electric tariff needs further revision to make it more helpful to tubewell owners with small holdings. Under the new tariff the tubewell owners have to pay a lump sum share in the capital cost of electric facilities. The first Rs. 7,500/- are invested by WAPDA while any amount in

excess of Rs. 7,500/- is to be paid by the consumers which is causing hardship. The following suggestions are put forward for consideration:

i) The share of the capital cost may be converted to a monthly rental basis of 1 percent of the capital cost per mensem as is the case for industrial consumers.

or ii) The share of the capital cost may be recovered over a ten year period with interest against a bank quarantee.

8. Assured supplies of good quality diesel oil at reasonable rates must be provided to farmers with diesel tubewells. A general difficulty faced by these farmers is that they have to transport diesel oil from long distances and at the time that there is a shortage of diesel the farmers have to pay higher rates.

9. Government should encourage workshop facilities for repair and maintenance of diesel and electric tubewells. These facilities may be provided by the manufacturers at central stations. In the absence of such facilities unskilled 'Mistries' poorly handle such jobs of repair and consequently create additional problems for the tubewell owners.

10. Pumps, electric motors, and diesel engines of different capacities are now extensively manufactured at many places in the country, but there are few manufacturers who strictly maintain quality control in materials and design. The result is that these locally manufactured units are available at lower prices than foreign made units or those made by competent manufacturers who observe quality control. The farmers generally go after the cheaper sets. Ultimately they are the losers when the unit

proves to be less durable and inefficient. It is, therefore, recommended that the government should take suitable steps to ensure that the pumps, motors and engines manufactured domestically maintain standard specifications and design.

The government should also through some of its organizations, take steps to insure that necessary materials for the installation of tubewells are easily available at reasonable rates.

11. At present a 25 percent rebate in canal water rate is allowed to the farmers utilizing tubewell water. The procedure of getting this rebate is quite cumbersome. Instead it is recommended that the water rate be based on the amount of water delivered instead of basing it on the area irrigated. The measurement can be made by installing flumes at the distributaries.

12. The farmers seeking loans from Agricultural Development Bank have to face great difficulty. The interest rate of 8 percent is quite high. The procedure of getting loans should be simplified. The following recommendations are put forward for consideration in the case of Agricultural Development Bank of Pakistan.

    i) The farmers be allowed to purchase tubewell components from open market. The present practice of supplying the components through approved dealers be discontinued.

    ii) The interest rate be reduced. This can be achieved if the State Bank of Pakistan be allowed to lend more money at 3 percent interest to the Agricultural Development Bank of Pakistan.

    iii) The present tubewell capacity restrictions based on the irrigable area should be modified. Loans should be given for a one cusec capacity tubewell for areas exceeding 25 acres while at present a 1/2 cusec capacity tubewell is approved for areas of 25 to 50 acres.

9.3 General

1. Extension and advisory services are expected to be useful in helping the farmers with respect to selection of the size of the tubewell, installation of tubewells, and the allied problems they may face during construction. It is recommended that a 'Bureau of Technical and Agricultural Guidance to Farmers' be established at important centers which should provide free guidance to farmers and advise them about the water quality, soil conditions, crops that must be raised, use of fertilizer and plant protection, water required for different crops, and other related matters. It is suggested that these Bureaus be established at the Engineering Institutions at Lahore, Peshawar, Hyderabad, Dacca and Rajshahi and the Agricultural Universities of Lyallpur and Mymensingh. Some faculty members in related fields may be associated to the Bureaus in addition to their teaching and research assignments. The Bureaus may arrange for extension lecturers in different parts of the respective provinces, arrange for short duration courses for farmers and prepare literatures in regional languages for distribution among farmers.

2. Technical films about the benefits of tubewells, agriculture and the use of fertilizer and pesticides etc., should be prepared by the government and widely shown to the farmers.

3. Increase in cropped area due to tubewells results in increased consumption of fertilizer and pesticides. The fertilizer and

pesticide industries should also be encouraged so that adequate quantities of fertilizers are available at moderate prices.

4. Tubewells increase the cropped area as well as the average yields. Consequently, agricultural production increases. Agricultural production must be brought to markets and will require better communication facilities.

9.4 Suggested Study

The following proposal is submitted for the consideration of the Planning Commission as it is considered of immense value in increasing the efficiency of private tubewells.

9.5 Standardization of Tubewell Components

At present pumps, electric motors and diesel engines of various capacities are being manufactured in the country. There are very few manufacturers who strictly follow certain specifications in materials and design. As a result their products are not up to the required standard but at the same time these are cheaper than the materials manufactured by those manufacturers who observe quality control. The farmers are lured by the low price of the cheaper product and ultimately they are the losers when the units prove to be less durable and inefficient.

It is, therefore, suggested that certain standards be specified which every manufacturer would be required to strictly follow. A study is required to prescribe these standards.

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APPENDIX A

OLD PROFORMA

APPENDIX A - Continued

INFORMATION TO BE COLLECTED

MAIN HEADLINES

A. Location and Preliminary Information etc.

B. Ownership

C. Capital Source Rate of Interest

D. Questions Regarding Construction Features

E. Performance Test (Separate analysis for electric and diesel engines)

   (i) Cost of construction (expected life of various components)

   (ii) Operating cost

F. Farm operation characteristics

   (a) Pretubewell condition

   (b) Conditions after the tubewell has been installed

G. Soil Classification and Soil Characteristics

H. Water Quality

I. Cost Analysis

J. General

A. LOCATION ETC.

(i) Name of interviewer _____

(ii) Helped by (s) _____

(iii) Date of interview _____

Name(s) of person(s) interviewed whether educated

_____

_____

_____

(iv) Location

(a) District _____

(b) Tehsil _____

(c) Perennial area _____

(d) Non-perennial area _____

(e) Barani area _____

(f) Union Council _____

(g) Consumer No. _____

(h) Sub-Division _____

Is there any other tubewell in the vicinity? If yes, give details.

a short note and sketch of location of tubewell.

Depth of tubewell.

Age of tubewell.

B. OWNERSHIP

Owner:

Ownership single or joint

If single - name and address - occupation of owner

If joint - names and addresses etc.

Date of installation _____.

C. SOURCE OF CAPITAL

Personal or borrowed:

From Bank (Name) _____

From Co-operative Society (Name) _____

Rate of Interest _____

In how much time money was returned or is expected to be returned?

D. CONSTRUCTION FEATURES

(a) Equipment data:

Pump Type _____ Cost _____ Motor Make _____

Pump Make _____ Horse Power _____

Rated Head (H) _____ Operation Voltage _____

Operating Speed (rpm) _____ Power Factor _____

Lubrication _____ KWH Motor Make _____

No. of Impellors/Bowls _____

Colume Pipe (dia) _____

Length _____

(b) Materials data:

Length of Blind Pipe _____ Material _____

Diameter of Blind Pipe _____ Manufacturer _____

Length of Strainer _____ Material _____

Diameter of Strainer _____ Manufacturer _____

Percentage of open area in the strainer _____

(c) Method of installation:

Installed by whom (Name of driller on _____

Date of installation: _____

Method of installation: _____

Time spent in installation: _____

PERFORMANCE TEST, CONSTRUCTION & OPERATION COSTS

Depth of Bore _____ Time for which tubewell is operated during 24 hours _____

Depth of Pitbore _____

Water Table Depth _____ In Rabi _____

Suction Head _____ In Kharif _____

Friction Head _____ Is canal water available? If yes, for how much period?

Velocity Head _____

Discharge Head _____ Is it used by the owner? _____

Total Head _____ If not, at which rate is it sold? _____

Discharge _____ (Source of information)

Power Consumed _____

Any operator _____

Empluments of the operator _____

No. of breakdowns in a season _____

Cause of breakdown _____

Expenditure _____

To rectify _____

Defect locally rectified _____

E. PERFORMANCE TEST

Is tubewell water sold? _____

At which rate? _____

Earnings from sale of water _____

(a) Kharif _____

(b) Rabi _____

Total length of water course: _____

Cost of construction water course: _____

FARM OPERATION CHARACTERISTICS

F. FARMS

(1) Location _____ Owner _____ single - joint

(2) Area _____ Irrigated by Manual / Mechanical

Owner or leased _____

(3) Culturable area _____

Kharif:

Crop _____

Area under cultivation _____

%age under cultivation _____

Method of cultivation: Manual / Mechanical

Yield in maunds: _____ in Rs. _____

(4) Area irrigated:

	AREA IN ACRES		CROP VALUE IN Rs.	
	KHARIF	RABI	KHARIF	RABI
By tubewell alone				
By perennial canal alone				
By seasonal canal alone				
By tubewell as well as canal				

(5) No. of days tubewell is operated in a year _____days.

Rabi

Crop _____

Area under cultivation _____

%age area under cultivation _____

Method of cultivation: Manual
Mechanical

Yield in maunds _____ in Rs. _____

G. SOIL CLASSIFICATION:

Subsoil texture:

(a) Sand to loamy sand — Coarse textured soil

(b) Sandy loam to fine sandy loam — Medium textured soil

(c) Loam to silt loam — Fine textured soil

(d) Clay loam to silty Clay loam

Soil texture	Bulk density	Permeability Characteristics	Soil Fertility

H. WATER QUALITY _____ Total solid _____

I. COST ANALYSIS

(a) Capital cost of tubewell

(b) Operation cost of tubewell

(c) Expenditure on the farm

J. GENERAL

Reasons for installing tubewell and if purpose accomplished?

(a) Procurement of diesel oil per year _____ gallons.

(b) Whether fuel easily available? Yes_____ No_____

(c) No. of days not worked during the last 12 months _____days.

(d) How installation financed?

(i) Own cash Rs. _____

(ii) Agriculture bank loan Rs. _____

(iii) Loan from cooperatives Rs. _____

(iv) Loan from commercial bank Rs. _____

(v) Loan from friends/relatives Rs. _____

(vi) Loan from landlords Rs. _____

(e) Difficulties (if any)

(i) Getting credit _____

(ii) Getting boring rig _____

(iii) Procurement of pipe _____

(iv) Procurement of strainer _____

(v) Obtaining engine/electric motor _____

(vi) Spare parts _____

(vii) Repairs _____

(viii) No difficulty _____

(f) (For persons having canal as well as tubewell irrigation)

(i) Do you have to pay more 'abiana' since you installed the tubewell: _____Yes _____No

(ii) If yes, state the yearly amount: Rs. _____

Before tubewell _____

After tubewell _____

APPENDIX B

NEW PROFORMA

LOCATION DATA

Province E = East W = West
Division _____ District _____ Tehsil _____
Canal Command _____
Doab _____ Project _____
Union Council Number
Subdivision Number
Consumer Number
Distance to nearest Diesel tubewell-nearest 0.1 mile
PU = Public PR = Private
Distance to nearest Electric tubewell-nearest 0.1 mile
PU = Public PR = Private
Distance to nearest Open well-nearest 0.1 mile
PU = Public PR = Private
Distance to nearest Canal-nearest 0.1 mile

PHYSICAL CHARACTERISTICS OF TUBEWELL

Tubewell type D = Diesel E = Electric C = Diesel Electric
Year of Installation
Drilling Depth- feet
Diameter - inches
Pit Depth- feet
Delivery Pipe Length- feet
Diameter - inches
Blind Pipe Length- feet
Diameter - inches
Strainer Length- feet
Diameter - inches
Pump Type C = Centrifugal T = Turbine
Make _____ Rated Head-feet ____ 0.1
Operating Speed rpm.
Rated Discharge cfs.
Motor Lubricant O = Oil W = Water
Make _____ Horse Power ____ 0.1
Operative Voltage
Power Factor ____ 0.01
Energy Meter Reading rev/kwh ____ 0.1
rev/min
Make _____ Power hp
Operating Head - feet
Depth of water table at time of installation - feet
Depth of water table now - feet

Jet Coordinates 0.01-feet Velocity 0.1-feet
X Y

Ave. Velocity ft/sec 0.1

Jet Diameter 0.01-feet
Tubewell Capacity cfs 0.01
(ac.ft/hr 0.01)

Area sqft 0.01

INSTALLATION INFORMATION

Method B = Both H = Hand percussion M = Mechanical
Type labour A = Approved govt. cont. O = Other P = Private labour S = Self
Time required for installation days
Time required for electrical connection days
Electric Supply I = Irregular R = Regular
Length of lead - nearest 0.1 mile
Diesel supply easily available Y = Yes N = No
Distance to nearest diesel depot 0.1 mile
Number of days in last 12 mo. out of operation due to no Fuel or Electricity

FARM OPERATING CHARACTERISTICS

Area Type B = Barani N = Nonperenial P = Perenial
Total Acreage of Farm
Irrigable
Irrigated.
Barani.
Saline.
Water-logged.
Farm O = Owned L = Leased. B = Both
Lease rate per acre
Number of owners
Occupation of owners F = Farmer O = Other
Irrigation A = Manual E = Mechanical B = Both
Soil texture C = Clay A = Sand I = Silt
Soil fertility A = Average G = Good P = Poor
Condition of surrounding land A = Average G = Good P = Poor
Relative flatness N = No ponding P = Ponding
%Owned
Number of persons above 10 yrs. age working on farm
Annual expenditure for labour
Number of work animals
Annual expenditure for animals
Number of tractors
Acres your tractor works : Yours
Others
Hours your tractor rented per year
Rate you charge Rs./hr. ____ 0.1
Hours you hire a tractor per year
Rate you pay for tractor Rs./hr ____ 0.1
Total length of lined water course
Total cost of lined water course

WATER DATA

IRRIGATION WATER AVAILABLE

Quality
EC x 10^6 at 25°c
RSC—Residual Sodium Carbonate
SAR—Sodium Absorptiod Ratio

Annual Rainfall Inches

Canal water
Y = Yes N = No
N = Nonperenial P = Perenial
Begin Date (Week = 1—4 and month)
End Date (Week = 1—4 and month)
Hours per day Kharif
Rabi
Number of days Kharif
Rabi
Cubic feet per hour

Open well water
Y = Yes N = No
N = Nonperenial P = Perenial
Begin Date (Week = 1—4 and month)
End Date (Week = 1—4 and month)
Hours per day Kharif
Rabi
Number of days Kharif
Rabi
Cubic feet per hour

Tubewell water
Hours per day Kharif
Rabi
Number of days Kharif
Rabi
Cubic feet per hour

IRRIGATION WATER USE

Total Acres Irrigated by canal	Kharif	____	0.1
	Rabi	____	0.1
Total Abiana	Kharif		
	Rabi		
Total Acres Irrigated by open well	Kharif	____	0.1
	Rabi	____	0.1
Total Acres Irrigated by tubewell	Kharif	____	0.1
	Rabi	____	0.1

Total Acres Irrigated	Kharif
%Canal water	
%Open well water	
%Tubewell water	
Total Acres Irrigated	Rabi
%Canal water	
%Open well water	
%Tubewell water	

ECONOMIC DATA FOR TUBEWELL

CONSTRUCTION EXPENSES

COST FOR	MATERIALS	LABOUR	TOTAL
Water Test			
Drilling			
Pipes			
Strainer			
Pump			
Motor			
Structure			
Electric Connection			
Misc.			
		TOTAL	

OPERATING EXPENSES

COST FOR	RUPEES/Yr.
Attendant	
Maintenance	
Electricity	
Diesel Oil	
Misc.	
TOTAL	

INCOME

Tubewell water sold Y = Yes N = No

Rate Rupees/hr. ____ 0.01

Average hours sold	Kharif	
	Rabi	
Average Income Rs.	Kharif	
Rs.	Rabi	
Total Average Income Rs.		

FINANCING

	1	2	3	4
Agricultural Bank				
Co-operative Bank				
Friends Relatives				
Headman				
Landowner				
Own Cash				
Other: Specify				

(1) Rupees
(2) Number of years
(3) %Interest 0.1
(4) Frequency of payment
A = Annual S = Semiannual
M = Monthly O = Other
Q = Quarterly Specify

TOTAL

COTTON

Total Acres : 0.1
Maunds Acre : 0.1
Rupees Maund : 0.01
Cost Data Acre : Seed
Fertilitzer
Pesticide
Labour
Other
Seed : lbs Acre
Harvest : MA = Manual ME Mechanical B = Both
Year first used : New Seed 19
Maunds/Acre.
New Fertilizer. 19
Maunds/Acre
Pesticide : 19
Maunds/Acre
Tubewell water : 19
Maunds/Acre
Yield Before Tubewell water : Maunds/Acre
Distance between plants : Inches
Distance between rows : Inches
Broadcast : N = No Y = Yes
Natural Disastors : D = Drought, F = Flood, I = Insect, N = None
Total No. of varieties of seed used this year—this crop
Fertilizer used on this crop : N = No. Y = Yes
Pesticide used on this crop : N = No. Y = Yes

SEED	DATE SOWN W MO	DATE REAPED W MO	IN PRE IRR	DATE FIRST IRR	DATE LAST IRR	TOT No IRR	AVE IN IRR
ACL 34							
C 134							
DESI							
LSS							
PAC-UP							
199F							

FERTILIZER	FIRST APP	LAST APP	No. APP	lbs/Ac APP
AMMONIUM SULPHATE				
AMMONIUM NITRATE				
DIAMMONIUM PHOSPHATE				
DESI				
SUPER PHOSPHATE				
UREA				

PESTICIDE	FIRST APP	LAST APP	No. APP	lbs Ac APP
D D T				
DI SYSTON				
DIMECRON PHOSPHENION (oz)				
ENDRIN				
MALATHION				
MENTHYL PARATHION				
SEVIN				
TEMIK				
THIMET				
TOXAPHENE				

MAIZE

Total Acres : 0.1
Maunds/Acre : 0.1
Rupees/Maund : 0.01
Cost Data/Acre : Seed
Fertilitzer
Pesticide
Labour
Other

Seed : lbs/Acre
Harvest : MA = Manual ME - Mechanical B = Both
Year first used : New Seed: 19
Maunds/Acre.
New Fertilizer: 19
Maunds Acre
Pesticide : 19
Maunds/Acre
Tubewell water : 19
Maunds/Acre
Yield Before Tubewell water : Maunds Acre
Distance between plants : Inches
Distance between rows : Inches
Broadcast : N = No Y = Yes
Natural Disastors : D = Drought, F = Flood, I = Insect, N = None
Total No. of varieties of seed used this year—this crop
Fertilizer used on this crop : N = No. Y = Yes
Pesticide used on this crop : N = No. Y = Yes

SEED	DATE SOWN W MO	DATE REAPED W MO	IN PRE IRR	DATE FIRST IRR	DATE LAST IRR	TOT No IRR	AVE IN IRR
DOUBLE 697							
DESI							
J 1							
SINGLE 113							
SINGLE 154							
SYNTHETIC 2							
SYNTHETIC 200							

FERTILIZER	FIRST APP	LAST APP	No. APP	lbs/Ac APP
AMMONIUM SULPHATE				
AMMONIUM NITRATE				
DIAMMONIUM PHOSPHATE				
DESI				
SUPER PHOSPHATE				
UREA				

PESTICIDE	FIRST APP	LAST APP	No. APP	lbs Ac APP
ENDRIN (spray or granules)				
SEVIN (granules)				

RICE

Total Acres : 0.1
Maunds Acre : 0.1
Rupees/Maund : 0.01
Cost Data Acre : Seed
Fertilitzer
Pesticide
Labour
Other

Seed : lbs Acre
Harvest : MA = Manual ME = Mechanical B = Both
Year first used : New Seed 19
Maunds/Acre.
New Fertilizer. 19
Maunds Acre
Pesticide : 19
Maunds/Acre
Tubewell water : 19
Maunds/Acre
Yield Before Tubewell water : Maunds Acre
Distance between plants : Inches
Distance between rows : Inches
Broadcast : N = No Y = Yes
Natural Disastors : D = Drought, F = Flood, I = Insect, N = None
Total No. of varieties of seed used this year—this crop
fertilizer used on this crop : N = No. Y = Yes
Pesticide used on this crop : N = No. Y = Yes

SEED	DATE SOWN W MO	DATE REAPED W MO	IN PRE IRR	DATE FIRST IRR	DATE LAST IRR	TOT No IRR	AVE IN/IRR
BASMATI 370							
BASMATI 622							
DESI							
IRR 8							
JHONA 160							
JHONA 349							
MUSHKIN							
PERMAL							

FERTILIZER	FIRST APP	LAST APP	No. APP	lbs/Ac APP
AMMONIUM SULPHATE				
AMMONIUM NITRATE				
DIAMMONIUM PHOSPHATE				
DESI				
SUPER PHOSPHATE				
UREA				

PESTICIDE	FIRST APP	LAST APP	No. APP	lbs Ac APP
DIAZINON 146				
DIMECRON				

SUGARCANE

Total Acres : 0.1
Maunds/Acre : 0.1
Rupees/Maunds : 0.01
Cost Data/Acre : Seed
Fertilizer
Pesticide
Labour
Other

Seed : lbs Acre
Harvest : MA = Manual ME = Mechanical B = Both
Year first used : New Seed 19
Maunds/Acre.
New Fertilizer. 19
Maunds/Acre
Pesticide : 19
Maunds/Acre
Tubewell water : 19
Maunds/Acre
Yield Before Tubewell water : Maunds/Acre
Distance between plants : Inches
Distance between rows : Inches
Broadcast : N = No Y = Yes
Natural Disastors : D = Drought, F = Flood, I = Insect, N = None
Total No. of varieties of seed used this year—this crop
Fertilizer used on this crop : N = No. Y = Yes
Pesticide used on this crop : N = No. Y = Yes
Planting : 1 = Newly Planted, 2 = 2nd cutting, 3 = 3rd cutting etc.

SEED	DATE SOWN W MO	DATE REAPED W MO	IN PRE IRR	DATE FIRST IRR	DATE LAST IRR	TOT No IRR	AVE IN IRR
BL 4							
BL 19							
DESI							
L 54							
PR 1000							

FERTILIZER	FIRST APP	LAST APP	No. APP	lbs/Ac APP
AMMONIUM SULPHATE				
AMMONIUM NITRATE				
DIAMMONIUM PHOSPHATE				
DESI				
SUPER PHOSPHATE				
UREA				

PESTICIDE	FIRST APP	LAST APP	No. APP	lbs/Ac APP
ALDRIN				
DIAZINON				
DIELDRIN				
ENDRIN				
SEVIN				

WHEAT

Total Acres : 0.1
Maunds/Acre : 0.1
Rupees/Maund : 0.01
Cost Data/Acre : Seed
Fertilitzer
Pesticide
Labour
Other

Seed : lbs/Acre
Harvest : MA = Manual ME = Mechanical B = Both
Year first used : New Seed 19
Maunds/Acre.
New Fertilizer 19
Maunds/Acre
Pesticide : 19
Maunds/Acre
Tubewell water : 19
Maunds/Acre
Yield Before Tubewell water : Maunds Acre
Distance between plants : Inches
Distance between rows : Inches
Broadcast :
Natural Disastors : D = Drought, F = Flood, I = Insect, N = None
Total No. of varieties of seed used this year—this crop
fertilizer used on this crop : N = No. Y = Yes
Pesticide used on this crop : N = No. Y = Yes

SEED	DATE SOWN W MO	DATE REAPED W MO	IN PRE IRR	DATE FIRST IRR	DATE LAST IRR	TOT No. IRR	AVE IN IRR
DESI							
DESI C 273							
MEXI PAK RED							
MEXI PAK WHITE							
MEXI PAK PENJAMO							
MEXI PAK INDUS							
MEXI PAK LERMARGO 14							
NORTENO							

FERTILIZER	FIRST APP	LAST APP	No. APP	lbs/Ac APP
AMMONIUM SULPHATE				
AMMONIUM NITRATE				
DIAMMONIUM PHOSPHATE				
DESI				
SUPER PHOSPHATE				
UREA				

PESTICIDE	FIRST APP	LAST APP	No. APP	lbs/Ac APP
BHC				
DIELDRIN				

Total Acres : 0.1
Maunds/Acre : 0.1
Rupees/Maund : 0.01
Cost Data/Acre : Seed
Fertilitzer
Pesticide
Labour
Other

Seed : lbs/Acre
Harvest : MA = Manual ME = Mechanical B = Both
Year first used : New Seed: 19
Maunds/Acre.
New Fertilizer: 19
Maunds/Acre
Pesticide : 19
Maunds/Acre
Tubewell water : 19
Maunds/Acre
Yield Before Tubewell water : Maunds/Acre
Distance between plants : Inches
Distance between rows : Inches
Broadcast : N = No Y = Yes
Natural Disastors : D = Drought, F = Flood, I = Insect, N = None
Total No. of varieties of seed used this year—this crop
fertilizer used on this crop : N = No. Y = Yes
Pesticide used on this crop : N = No. Y = Yes

SEED	DATE SOWN W MO	DATE REAPED W MO	IN PRE IRR	DATE FIRST IRR	DATE LAST IRR	TOT No. IRR	AVE IN/IRR

FERTILIZER	FIRST APP	LAST APP	No. APP	lbs/Ac APP

PESTICIDE	FIRST APP	LAST APP	No. APP	lbs Ac APP

FODDER AND VEGETABLES

Kharif: Total Acres 0.1
%, Used
%, Sold
Cost: Seed Fertilizer Pesticide
Income:
Number of Irrigations / year
Inches / Irrigation

Rabi : Total Acres 0.1
%, Used
%, Sold
Cost: Seed Fertilizer Pesticide
Income :
Number of Irrigations / year
Inches / Irrigation

Harvest: A = Manual E = Mechanical B = Both

Yield due to tubewell has (1) Remained the same
(2) Increased slightly
(3) Increased moderately
(4) Doubled
(5) More than doubled

GENERAL

Canal water available at time of installation: Y Yes N = No
Reason for installing tubewell
Purpose accomplished: Y = Yes N = No
Has tubewell maintained its discharge: Y = Yes N = No
Why not:
Any change in water quality since installation Y = Yes N No
In what way
Difficulty if any getting: Attendant
Boring
Credit
Electric Hook-up
Fertilizer
Fuel
Harvest Equipment
Labour
Motor
Permit
Pesticide
Pipe
Pump
Repair
Seed
Spare Parts
Strainer
Other: Specify
No Difficulties
Transportation of Material

Interviewer: _____ Date: _____
Helped by: _____ Time Req. _____
Name (1) Owner _____
Address _____
(2) Owner _____
Address _____
Name Person Interviewed: _____
Address: _____
Level of Education A = 1-5 B = 5-10 C College D = None
Relationship to Owner: B = Brother O = Owner S = Son T = Tenant N None
Reliability of Information: 0,25,50,75 or 100%
No. of cards for crops (Cards numbered 12 to 36)

APPENDIX C

NUMBER OF PRIVATE TUBEWELLS IN WEST PAKISTAN BY TEHSIL

APPENDIX C - Continued

NUMBER OF PRIVATE TUBEWELLS IN WEST PAKISTAN BY TEHSIL

(Projections Based on Survey Data)

Tehsil/District/Division	Diesel	Electric	Total
1	2	3	4
Abbottabad	2	4	6
Haripur	7	37	44
Mansehra	-	4	4
Battgram	-	-	-
HAZARA DISTRICT (Subtotal)	9	45	54
Mardan	5	372	377
Swabi	16	318	334
MARDAN DISTRICT (Subtotal)	21	690	711
Peshawar	4	71	75
Nowshera	2	733	735
Charsadda	-	109	109
PESHAWAR DISTRICT (Subtotal)	6	913	919
Kohat	10	190	200
Karak	1	60	61
Hangu	8	8	16
KOHAT DISTRICT (Subtotal)	19	258	277
Dir State	-	1	1
Khyber Agency	-	-	-
MALAKAND DIVISION (Subtotal)	20	100	120
PESHAWAR & MALAKAND DIVISIONS	75	2,007	2,082
Bannu	11	9	20
Lakki	4	14	18
BANNU DISTRICT (Subtotal)	15	23	38
D. I. Khan	73	468	541

APPENDIX C - Continued

1	2	3	4
Tank	1	-	1
Kalachi	-	-	-
D. I. KHAN DISTRICT (Subtotal)	74	468	542
South Waziristan Agency	10	-	10
North Waziristan Agency	-	-	-
D. I. KHAN DIVISION	99	491	590
Rawalpindi	21	17	38
Murree	-	1	1
Kahuta	2	-	2
Gujar Khan	9	2	11
RAWALPINDI DISTRICT (Subtotal)	32	20	52
Campbellpur	5	244	249
Fateh Jang	5	-	5
Pindi Gheb	9	-	9
Talagang	12	6	18
CAMPBELLPUR DISTRICT (Subtotal)	31	250	281
Jhelum	48	64	112
Chakwal	1	-	1
Pind Dadan Khan	79	-	79
JHELUM DISTRICT (Subtotal)	128	64	192
Gujrat	557	772	1,329
Phalia	277	136	413
Kharian	65	171	236
GUJRAT DISTRICT (Subtotal)	899	1,079	1,978
RAWALPINDI DIVISION	1,090	1,413	2,503

APPENDIX C - Continued

1	2	3	4
Bhakhar	284	279	563
Isakhel	3	176	179
Mianwali	109	194	303
MIANWALI DISTRICT (Subtotal)	396	649	1,045
Khusnab	73	54	127
Bhalwal	147	240	387
Sargodha	89	46	135
Shahpur	129	169	298
SARGODHA DISTRICT (Subtotal)	438	509	947
Jhang	1,444	896	2,340
Chiniot	644	883	1,527
Shorkot	766	414	1,180
JHANG DISTRICT (Subtotal)	2,854	2,193	5,047
Lyallpur	324	262	586
Jaranwala	255	113	368
Samundri	1,131	457	1,588
T.T.Singh	1,138	807	1,945
LYALLPUR DISTRICT (Subtotal)	2,848	1,639	4,487
SARGODHA DIVISION	6,536	4,990	11,526
Sialkot	912	764	1,676
Narowal	801	113	914
Pasrur	986	50	1,036
Shakargarh	208	14	222
Daska	3,126	871	3,997
SIALKOT DISTRICT (Subtotal)	6,033	1,812	7,845

APPENDIX C - Continued

1	2	3	4
Hafizabad	1,151	291	1,442
Wazirabad	1,876	885	2,761
Gujranwala	3,195	1,863	5,058
GUJRANWALA DISTRICT (Subtotal)	6,222	3,039	9,261
Sheikhupra	332	272	604
Ferozewala	517	1,098	1,615
Nankana Saheb	371	367	738
SHEIKHUPURA DISTRICT (Subtotal)	1,220	1,737	2,957
Kasur	766	1,194	1,960
Chunian	697	844	1,541
Lahore	119	1,934	2,053
LAHORE DISTRICT (Subtotal)	1,582	3,972	5,554
LAHORE DIVISION	15,057	10,560	25,617
Sahiwal	1,632	1,247	2,879
Okara	754	495	1,249
Depalpur	1,888	2,172	4,060
Pakpattan	3,968	1,313	5,281
SAHIWAL DISTRICT (Subtotal)	8,242	5,227	13,469
Multan	1,304	518	1,822
Khanewal	1,529	731	2,260
Kabirwala	1,237	71	1,308
Lodhran	1,822	43	1,865
Vehari	765	1,293	2,058
Shujabad	1,059	76	1,135
Mailsi	1,651	58	1,709
MULTAN DISTRICT (Subtotal)	9,367	2,790	12,157

APPENDIX C - Continued

1	2	3	4
Muzaffargarh	356	20	376
Laiah	531	50	581
Kot Adu	182	37	219
Ali Pur	329	2	331
MUZAFFARGARH DISTRICT (Subtotal)	1,398	109	1,507
D.G.Khan	416	12	428
Taunsa	38	12	50
Jampur	117	-	117
Rajanpur	439	-	439
D. G. KHAN DISTRICT (Subtotal)	1,010	24	1,034
MULTAN DIVISION	20,017	8,150	28,167
Bahawalpur	457	126	583
Hasilpur	643	151	794
Ahmadpur East	310	80	390
BAHAWALPUR DISTRICT (Subtotal)	1,410	357	1,767
Bahawalnagar	272	64	336
Fort Abbas	22	24	46
Minchinabad	277	22	299
Chishtian	297	64	361
BAHAWALNAGAR DISTRICT (Subtotal)	868	174	1,042
Rahim Yar Khan	87	451	538
Khanpur	313	82	395
Liaqatpur	287	17	304
Sadiqabad	440	40	480
RAHIM YAR KHAN DISTRICT(Subtotal)	1,127	590	1,717
BAHAWALPUR DIVISION	3,405	1,121	4,526

APPENDIX C - Continued

1	2	3	4
Jaccobabad	9	1	10
Garhi Khairo	-	-	-
Kand Kot	30	36	66
Kashmore	95	1	96
Thul	12	11	23
Usta Mohammad	2	-	2
Jhat Pat	6	-	6
JACCOBABAD DISTRICT (Subtotal)	154	49	203
Shikarpur	50	8	58
Rohri	18	17	35
Ghotki	50	76	126
Pano Akil	61	40	101
Abauro	171	22	193
Sukkur	10	49	59
Mirpur Mathelo	24	-	24
Garhi Yasin	-	-	-
SUKKUR DISTRICT (Subtotal)	384	212	596
Shahdad Kot	5	2	7
Kamber	3	1	4
Miro Khan	-	-	-
Werah	2	1	3
Ratto Dero	4	6	10
Dokri	37	4	41
Larkana	8	19	27
LARKANA DISTRICT (Subtotal)	59	33	92
Khairpur	31	70	101
Mirwah	-	-	-
Nara	3	5	8

APPENDIX C - Continued

1	2	3	4
Gambat	9	30	39
Faiz Ganj	1	2	3
Kot Diji	-	-	-
KHAIRPUR DISTRICT (Subtotal)	44	107	151
Kandiaro	36	16	52
Maushero Feroze	69	8	77
Moro	25	22	47
Nawabshah	10	13	23
Sakrand	70	22	92
NAWABSHAH DISTRICT (Subtotal)	210	81	291
KHAIRPUR DIVISION	851	482	1,333
Hyderabad	20	47	67
Hala	20	72	92
Tando Allahyar	9	50	59
Tando Mohammad Khan	-	-	-
Matli	7	5	12
Tando Bago	1	1	2
Badin	-	-	-
HYDERABAD DISTRICT (Subtotal)	57	175	232
Sanghar	2	-	2
Khipro	-	-	-
Sinjhoro	2	-	2
Shahdadpur	10	75	85
SANGHAR DISTRICT (Subtotal)	14	75	89
Dadu	7	4	11
Jbhi	29	10	39
Khairpur Nathan Shah (Subtotal)	6	3	9

APPENDIX C - Continued

1	2	3	4
Kotri	6	2	8
Sehwan	9	8	17
Mehar	18	6	24
DADU DISTRICT (Subtotal)	75	33	108
Mirpur Khas	-	3	3
James Abad	10	5	15
Digri	-	2	2
Samaro	-	-	-
Umerkot	1	-	1
Diplo	1	-	1
Mitho	-	-	-
Chachro	-	-	-
Nagarpakar	-	-	-
THARPARKAR DISTRICT (Subtotal)	12	10	22
Thatta	25	-	25
THATTA DISTRICT (Subtotal)	25	-	25
HYDERABAD DIVISION	183	293	476
Fort Sandeman	61	-	61
Killa Saifullah	87	-	87
Hindu Bagh	10	-	10
Sherani	16	-	16
ZHOB DISTRICT (Subtotal)	174	-	174
Bori	23	-	23
Musa Khel	2	-	2
Duki	13	-	13
Barkhan	12	-	12
Sanjawai	1	-	1
LORALAI DISTRICT (Subtotal)	51	-	51

APPENDIX C - Continued

1	2	3	4
Quetta	28	117	145
Pishin	163	261	424
Chaman	11	-	11
QUETTA DISTRICT (Subtotal)	202	378	580
Sibi	1	-	1
Kohiu	1	-	1
Shah Rag	-	-	-
Dera Bagti	-	-	-
SIBI DISTRICT (Subtotal)	2	-	2
Naushki	56	1	57
Dalbandiu	56	-	56
Naukundi	11	-	11
CHAGAI DISTRICT (Subtotal)	123	1	124
QUETTA DIVISION	552	379	931
Mastung	157	179	336
Kalat	41	-	41
Khuzdar	26	-	26
Vadh	2	-	2
Mashkey	3	1	4
KALAT DISTRICT (Subtotal)	229	180	409
Kharan	17	-	17
Wasnuk Subten	5	-	5
Rakhshan	3	-	3
KHARAN DISTRICT (Subtotal)	25	-	25
Turbat	36	-	36
Panjjur	8	-	8
Tump	1	-	1

APPENDIX C - Continued

1	2	3	4
Pasni	1	-	1
Jiwani	1	-	1
Dasht Khuddan Subteh	2	-	2
Kolwah	3	-	3
Gwadar	4	-	4
MEKRAN DISTRICT (Subtotal)	56	-	56
Dhadar	4	-	4
Lehri	1	-	1
Jhal Magri	4	-	4
KACHHI DISTRICT (Subtotal)	9	-	9
KALAT DIVISION	319	180	499
Lasbella	-	1	1
Uthal	-	5	5
Sonmiani	4	11	15
Dureji	8	1	9
Hub	8	29	37
LASBELLA DISTRICT (Subtotal)	20	47	67
Karachi	316	600	916
KARACHI DISTRICT (Subtotal)	316	600	916
KARACHI DIVISION	336	647	983
WEST PAKISTAN	48,520	30,713	79,233

APPENDIX D

MISCELLANEOUS TABLES

TABLE	TITLE
D-1	Area Owned by Tubewell Owners in Different Holding Sizes
D-2	Area Irrigated by Private Tubewells
D-3	Tubewells Installed on Canal Irrigated Lands
D-4	Cropping Intensity on Tubewells Irrigated Lands
D-5	Cropping Pattern on Lands where Tubewell is in Addition to Seasonal Canal
D-6	Area under Different Crops on Lands where Tubewell is in Addition to Seasonal Canal
D-7	Cropping Pattern on Lands where Tubewell is in Addition to Perennial Canal
D-8	Area under Different Crops on Lands where Tubewell is in Addition to Perennial Canal
D-9	Cropping Pattern on Lands where Tubewell is Only Source
D-10	Area under Different Crops on Lands where Tubewell is Only Source

APPENDIX D - Continued

TABLE D-1

AREA OWNED BY TUBEWELL OWNERS IN DIFFERENT HOLDING SIZES

No.	Division	Area in Thousand Acres										
		Upto 10 Acres	11-25 Acres	26-50 Acres	51-75 Acres	76-100 Acres	101-150 Acres	151-200 Acres	201-300 Acres	301-500 Acres	Above 500 Acres	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Peshawar & Malakand	8.1	5.3	5.7	4.5	3.9	1.7	-	-	-	-	29.2
	%age :	27.55	18.26	19.36	15.55	13.38	5.90	-	-	-	-	100.00
2.	D. I. Khan	0.1	1.3	7.5	6.1	3.4	18.8	1.9	2.9	18.5	-	60.5
	%age :	0.19	2.22	12.39	10.03	5.54	31.12	3.15	4.78	30.58	-	100.00
3.	Rawalpindi	5.3	20.1	16.1	7.4	6.5	2.1	-	4.3	-	-	61.8
	%age :	8.60	32.53	26.09	11.98	10.47	3.44	-	6.89	-	-	100.00
4.	Sargodha	7.2	57.8	101.6	117.9	93.0	190.1	104.5	89.5	25.2	-	786. 7
	%age :	0.91	7.35	12.92	14.98	11.82	24.16	13.29	11.38	3.20	-	100.00
5.	Lahore	23.3	192.8	329.1	173.6	88.5	71.7	3.9	4.8	8.6	-	896.2
	%age :	2.60	21.15	36.72	19.37	9.87	8.01	0.43	0.54	0.96	-	100.00
6.	Multan	6.0	138.5	365.7	346.8	336.7	255.4	113.0	102.4	34.2	15.0	1713.4
	%age :	0.35	8.08	21.34	20.24	19.65	14.90	6.59	5.97	1.99	0.88	100.00
7.	Bahawalpur	0.4	18.3	56.9	48.1	56.0	63.2	38.3	54.4	40.8	-	376.4
	%age :	0.10	4.86	15.12	12.78	14.88	16.79	10.17	14.45	10.85	-	100.00
8.	Khairpur	0.4	1.8	11.8	6.9	22.8	17.3	24.3	38.8	43.0	32.8	199.9
	%age :	0.21	0.92	5.93	3.43	11.39	8.65	12.17	19.42	21.48	16.40	100.00
9.	Hyderabad	0.1	0.9	3.3	5.9	8.3	9.4	2.7	9.4	14.2	6.8	60.9
	%age :	0.16	1.40	5.41	9.74	13.56	15.48	4.43	15.40	23.25	11.15	100.00
10.	Quetta	-	2.2	17.2	9.3	13.6	7.5	-	6.0	-	-	55.8
	%age :	-	3.92	30.73	16.67	24.34	13.52	-	10.82	-	-	100.00

Continued.....

Continued:: Table D-1

1	2	3	4	5	6	7	8	9	10	11	12	13
11.	Kalat	1.4	2.7	3.1	3.7	1.9	-	-	-	-	-	12.8
	%age :	10.93	20.96	23.95	29.19	14.97	-	-	-	-	-	100.00
12.	Karachi	0.8	4.2	16.6	4.8	6.4	11.1	4.9	-	-	-	48.7
	%age :	1.62	8.53	34.07	9.84	13.12	22.72	10.10	-	-	-	100.00
WEST PAKISTAN		53.0	445.9	934.5	735.1	640.7	648.4	293.5	312.5	184.4	54.6	4302.3
	%age :	1.23	10.36	21.72	17.09	14.89	15.07	6.82	7.26	4.29	1.27	100.00

TABLE D-2

AREA IRRIGATED BY PRIVATE TUBEWELLS

No.	Division	Area in Thousand Acres										
		Upto 10 Acres	11.25 Acres	26-50 Acres	51-75 Acres	76-100 Acres	101-150 Acres	151-200 Acres	201-300 Acres	301-500 Acres	Above 500 Acres	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Peshawar & Malakand	6.7	10.2	7.4	3.6	5.9	2.6	-	2.4	-	-	38.8
	%age :	17.35	26.38	18.97	9.19	15.23	6.82	-	6.08	-	-	100.00
2.	D. I. Khan	-	1.4	3.7	6.7	5.1	18.3	5.9	2.4	20.6	-	64.0
	%age :	-	2.14	5.71	10.42	7.95	28.52	9.25	3.82	32.16	-	100.00
3.	Rawalpindi	3.9	16.2	23.9	8.1	7.7	21.7	3.2	-	7.2	-	91.9
	%age :	4.21	17.64	26.06	8.78	8.38	23.63	3.52	-	7.78	-	100.00
4.	Sargodha	3.7	33.3	100.3	111.0	127.4	217.6	92.1	158.8	41.3	-	885.3
	%age :	0.42	3.76	11.33	12.53	14.39	24.58	10.40	17.93	4.66	-	100.00
5.	Lahore	5.6	119.2	341.1	318.3	236.4	193.4	57.2	30.0	16.0	-	1316.9
	%age :	0.42	9.05	25.90	24.17	17.95	14.69	4.34	2.28	1.22	-	100.00
6.	Multan	3.4	89.4	333.7	371.7	346.7	385.4	113.4	97.8	61.8	28.2	1831.2
	%age :	0.19	4.88	18.22	20.30	18.93	21.05	6.19	5.34	3.37	1.54	100.00
7.	Bahawalpur	0.8	13.9	56.7	45.9	48.5	63.1	24.5	76.6	46.6	23.1	399.7
	%age :	0.20	3.49	14.18	11.48	12.14	15.78	6.12	19.17	11.65	5.79	100.00
8.	Khairpur	0.3	1.7	7.2	10.7	14.7	27.3	30.4	26.2	42.7	75.1	236.3
	%age :	0.11	0.70	3.06	4.54	6.23	11.57	12.88	11.08	18.05	31.78	100.00
9.	Hyderabad	0.1	0.4	3.0	5.3	6.8	5.4	13.8	5.4	17.8	9.7	67.7
	%age :	0.13	0.61	4.45	7.75	10.08	7.96	20.42	7.91	26.33	14.36	100.00
10.	Quetta	0.5	3.1	16.0	13.4	2.3	6.9	9.3	-	-	-	51.4
	%age :	0.93	6.05	31.09	26.05	4.41	13.46	18.02	-	-	-	100.00

Continued.....

Continued.....Table D-2

1	2	3	4	5	6	7	8	9	10	11	12	13
11. Kalat		1.3	2.4	3.9	1.2	1.5	-	-	-	-	-	10.4
	%age :	12.59	23.24	37.69	11.67	14.81	-	-	-	-	-	100.00
12. Karachi		-	4.0	14.1	6.1	10.3	9.2	8.6	6.1	9.8	-	68.2
	%age :	-	5.82	20.62	8.97	15.09	13.50	12.60	9.00	14.40	-	100.00
WEST PAKISTAN		26.2	295.1	910.9	901.8	813.3	950.9	358.4	405.7	263.7	136.2	5061.9
	%age :	0.52	5.83	18.00	17.81	16.07	18.79	7.08	8.01	5.21	2.69	100.00

TABLE D-3

TUBEWELLS INSTALLED ON CANAL IRRIGATED LANDS

No.	Division	Tubewell Additional to Seasonal canal				Tubewell Additional to Perennial Canal			
		Number	Percent	Delivery Capacity (cusecs)	Area Irrigated 1000 Acres	Number	Percent	Delivery Capacity (cusecs)	Area Irrigated 1000 Acres
1.	Peshawar & Malakand	0.	-	-	-	35.	1.66	26.7	1.7
2.	D. I. Khan	58.	9.80	74.4	5.7	116.	19.61	139.7	8.5
3.	Rawalpindi	17.	0.68	14.8	1.1	-	-	-	-
4.	Sargodha	187.	1.62	227.5	20.3	5558.	48.22	6511.5	471.7
5.	Lahore	2992.	11.68	3551.5	208.0	2906.	11.34	2842.6	174.4
6.	Multan	8226.	29.21	8962.3	620.3	10704.	38.00	12417.0	624.4
7.	Bahawalpur	919.	20.30	1425.2	61.0	34.	0.75	74.9	3.4
8.	Khairpur	561.	42.06	531.6	110.6	476.	35.71	550.5	95.8
9.	Hyderabad	43.	8.96	25.5	5.8	362.	76.12	389.2	54.7
10.	Quetta	0.	-	0.0	-	0.	-	-	-
11.	Kalat	0.	-	0.0	-	19.	3.85	7.7	1.5
12.	Karachi	25.	2.50	9.8	0.8	0.	-	-	-
WEST PAKISTAN		13027.	16.44	14822.6	1033.5	20210.	25.51	22959.9	1436.1

TABLE D-4

CROPPING INTENSITY ON TUBEWELLS IRRIGATED LANDS

No.	Division	Area in Thousand Acres								
		Tubewell only source			Tubewell Additional to seasonal canal			Tubewell Additional to Perennial canal		
		Irrigable	Cropped	Intensity	Irrigable	Cropped	Intensity	Irrigable	Cropped	Intensity
1.	Peshawar & Malakand	27.5	37.1	135	-	-	-	1.4	1.7	123
2.	D. I. Khan	46.2	49.8	108	4.3	5.7	131	9.2	8.5	93
3.	Rawalpindi	60.9	90.8	149	0.7	1.1	155	-	-	-
4.	Sargodha	326.2	393.4	121	18.7	20.3	109	417.7	471.7	113
5.	Lahore	613.7	934.6	152	141.8	208.0	147	117.6	174. 4	148
6.	Multan	556.2	586.7	105	577.9	620.3	107	545.9	624.4	114
7.	Bahawalpur	303.3	335.2	110	61.7	61.0	99	3.4	3.4	100
8.	Khairpur	29.2	29.9	103	71.0	110.6	156	85.1	95.8	113
9.	Hyderabad	6.9	7.2	103	3.6	5.8	163	45.7	54.7	120
10.	Quetta	55.8	51.4	92	-	-	-	-	-	-
11.	Kalat	10.9	8.8	81	-	-	-	1.9	1.5	80
12.	Karachi	46.1	67.5	146	1.0	0.8	76	-	-	-
WEST PAKISTAN		1996.8	2509.4	126	924.8	1130.9	122	1251.8	1470.0	117

TABLE D-5

CROPPING PATTERN ON LAND WHERE TUBEWELL IS IN ADDITION TO SEASONAL CANAL

(% OF CROPPED AREA)

No.	Division	Cotton	Maize	Sugarcane	Rice	Wheat	Others	Vegetable & Fodder	Cropped Area
1.	Peshawar & Malakand	-	-	-	-	-	-	-	-
2.	D. I. Khan	-	8.62	13.89	18.05	24.32	11.99	23.12	100.00
3.	Rawalpindi	-	-	-	40.32	40.32	-	19.35	100.00
4.	Sargodha	21.18	7.55	16.02	0.74	31.86	-	22.65	100.00
5.	Lahore	3.21	0.05	2.70	38.13	43.60	0.37	11.93	100.00
6.	Multan	38.72	0.02	1.01	1. 05	40.57	1.71	16.92	100.00
7.	Bahawalpur	38.80	-	-	-	42.14	-	19.06	100.00
8.	Khairpur	8.46	2.02	1.98	35.07	26.32	18.94	7.22	100.00
9.	Hyderabad	6.47	4.88	0.31	24.36	19.23	15.20	29.55	100.00
10.	Quetta	-	-	-	-	-	-	-	--
11.	Kalat	-	-	-	-	-	-	-	--
12.	Karachi	-	-	-	-	-	1.96	98.04	100.00
WEST PAKISTAN		27.53	0.46	1.75	12.35	39.34	3.28	15.28	100.00

TABLE D-6

AREA UNDER DIFFERENT CROPS ON LANDS WHERE TUBEWELL IS IN ADDITION TO SEASONAL CANAL

(AREA THOUSAND ACRES)

No.	Division	Cotton	Maize	Sugarcane	Rice	Wheat	Others	Vegetable & Fodder	Cropped Area
1.	Peshawar & Malakand	-	-	-	-	-	-	-	-
2.	D. I. Khan	-	0.49	0.79	1.03	1.39	0.68	1.32	5.70
3.	Rawalpindi	-	-	-	0.43	0.43	-	0.20	1.06
4.	Sargodha	4.29	1.53	3.25	0.15	6.45	-	4.59	20.25
5.	Lahore	6.68	0.11	5.61	79.31	90.69	0.77	24.82	208.00
6.	Multan	240.17	0.14	6.25	6.54	251.62	10.61	104.93	620.26
7.	Bahawalpur	23.68	-	-	-	25.73	-	11.64	61.05
8.	Khairpur	9.35	2.23	2.19	38.78	29.11	20.94	7.98	110.59
9.	Hyderabad	0.38	0.28	0.02	1.42	1.12	0.88	1.72	5.82
10.	Quetta	-	-	-	-	-	-	-	-
11.	Kalat	-	-	-	-	-	-	-	-
12.	Karachi	-	-	-	-	-	0.01	0.74	0.75
WEST PAKISTAN		284.56	4.79	18.11	127.66	406.53	33.91	157.94	1033.48

APPENDIX D - Continued

TABLE D-7

CROPPING PATTERN ON LANDS WHERE TUBEWELL IS IN ADDITION TO PERENNIAL CANAL

(% OF CROPPED AREA)

No.	Division	Cotton	Maize	Sugarcane	Rice	Wheat	Others	Vegetable & Fodder	Cropped Area
1.	Peshawar & Malakand	6.64	26.58	30.56	-	33.22	-	2.99	100.00
2.	D. I. Khan	0.07	1.37	4.37	20.18	55.43	5.19	13.30	100.00
3.	Rawalpindi	-	-	-	-	-	-	-	100.00
4.	Sargodha	16.20	4.01	15.19	3.52	33.92	1.93	25.22	100.00
5.	Lahore	2.01	0.47	3.21	38.79	41.50	0.18	13.74	100.00
6.	Multan	36.62	0.44	1.39	1.67	39.20	1.81	18.88	100.00
7.	Bahawalpur	35.00	-	-	-	35.00	-	30.00	100.00
8.	Khairpur	17.34	1.14	6.23	21.52	33.92	11.40	8.46	100.00
9.	Hyderabad	40.19	1.17	8.20	-	35.70	5.01	9.73	100.00
10.	Quetta	-	-	-	-	-	-	-	-
11.	Kalat	-	-	-	-	62.50	-	37.50	100.00
12.	Karachi	-	-	-	-	-	-	-	-
	WEST PAKISTAN	24.27	1.73	6.77	8.15	37.37	2.43	19.29	100.00

TABLE D-8

AREA UNDER DIFFERENT CROPS ON LANDS WHERE TUBEWELL IS IN ADDITION TO PERENNIAL CANAL

(AREA THOUSAND ACRES)

No.	Division	Cotton	Maize	Sugarcane	Rice	Wheat	Others	Vegetable & Fodder	Cropped Area
1.	Peshawar & Malakand	0.12	0.46	0.53	-	0.58	-	0.05	1.73
2.	D. I. Khan	0.01	0.12	0.37	1.72	4.74	0.44	1.14	8.54
3.	Rawalpindi	-	-	-	-	-	-	-	-
4.	Sargodha	76.43	18.91	71.64	16.62	160.00	9.10	118.96	471.66
5.	Lahore	3.51	0.82	5.60	67.64	72.53	0.31	23.96	174.37
6.	Multan	228.64	2.74	8.68	10.42	244.73	11.33	117.86	624.37
7.	Bahawalpur	1.19	-	-	-	1.19	-	1.02	3.40
8.	Khairpur	16.62	1.09	5.97	20.62	32.51	10.93	8.10	95.84
9.	Hyderabad	21.98	0.64	4.49	-	19.52	2.74	5.32	54.69
10.	Quetta	-	-	-	-	-	-	-	-
11.	Kalat	-	-	-	-	0.96	-	0.58	1.54
12.	Karachi	-	-	-	-	-	-	-	-
WEST PAKISTAN		348.49	24.78	97.27	117.02	536.76	34.86	277.00	1436.15

TABLE-D-9

CROPPING PATTERN ON LANDS WHERE TUBEWELL IS ONLY SOURCE

(% OF CROPPED AREA)

No.	Division	Cotton	Maize	Sugarcane	Rice	Wheat	Others	Vegetable & Fodder	Cropped Area
1.	Peshawar & Malakand	0.50	34.72	10.11	-	34.00	10.55	10.13	100.00
2.	D. I. Khan	5.44	7.56	3.73	5.12	58.43	9.60	10.13	100.00
3.	Rawalpindi	2.59	0.40	7.93	28.57	38.75	0.82	29.93	100.00
4.	Sargodha	11.71	0.51	6.55	11.35	41.93	4.96	22.99	100.00
5.	Lahore	1.85	0.62	2.02	38.65	42.64	0.46	13.77	100.00
6.	Multan	34.35	0.53	1.99	5.51	48.26	0.87	8.49	100.00
7.	Bahawalpur	26.94	0.95	6.86	5.88	39.26	3.32	16.80	100.00
8.	Khairpur	34.10	3.02	4.03	0.14	42.13	5.13	11.44	100.00
9.	Hyderabad	28.80	3.96	2.47	1.19	42.95	9.80	10.84	100.00
10.	Quetta	-	-	-	-	52.48	32.02	15.50	100.00
11.	Kalat	-	-	-	-	61.09	12.83	26.09	100.00
12.	Karachi	-	0.18	-	-	-	17.59	82.23	100.00
WEST PAKISTAN		14.38	1.25	3.61	18.77	42.55	3.13	16.32	100.00

APPENDIX D - Continued

TABLE-D-10

AREA UNDER DIFFERENT CROPS ON LANDS WHERE TUBEWELL IS ONLY SOURCE

AREA (THOUSAND ACRES)

No.	Division	Cotton	Maize	Sugar-cane.	Rice	Wheat	Others	Vegetable & Fodder	Cropped Area
1.	Peshawar & Malakand	0.18	12.88	3.75	-	12.61	3.91	3.76	37.08
2.	D. I. Khan	2.71	3.76	1.85	2.55	29.08	4.78	5.04	49.78
3.	Rawalpindi	2.35	0.37	7.20	25.95	35.19	0.75	19.01	90.83
4.	Sargodha	46.09	2.01	25.79	44.65	164.96	19.51	90.45	293.45
5.	Lahore	17.26	5.79	18.85	361.25	398.55	4.27	128.68	934.63
6.	Multan	201.53	3.10	11.67	32.35	283.12	5.11	49.78	586.65
7.	Bahawalpur	90.32	3.18	22.99	19.70	131.61	11.13	56.30	335.23
8.	Khairpur	10.20	0.90	1.21	0.04	12.60	1.53	3.42	29.91
9.	Hyderabad	2.07	0.28	0.18	0.09	3.08	0.70	0.78	7.18
10.	Quetta	-	-	-	-	26.97	16.46	7.96	51.39
11.	Kalat	-	-	-	-	5.39	1.13	2.30	8.83
12.	Karachi	-	0.12	-	-	-	11.87	55.50	67.50
WEST PAKISTAN		372.71	32.39	93.49	486.59	1103.18	81.16	422.99	2592.45