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Informational Sources on Water Management for Agricultural Production in Pakistan With Special Reference to Institutional and Human Factors

VOLUME I

by

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Water Management Research
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of the Less Developed Countries

Colorado State University
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In Memoriam

The authors would like to dedicate these volumes to the :y of Abdur Rehman Rizwani, M.A., M.S., who died while lng to finish the work. Mr. Rizwani was known to his eagues as a quiet but thoughtful scholar whose judgments observations were always significant. Not one to be ed by popular opinions, he charted his own course and evered in it.

He will be best remembered by his gentle way with his orkers. His own views were always put forth with :eness but firmness. We appreciate his contributions ve honor his memory with this work.

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Garth N. Jones
Bashir Malik
Robert Schmidt

INTRODUCTION

"Irrigated agriculture is the most productive kind of farming devised by man."[1] It is also the most expensive and complicated. Its social requirements approach that of an industrial society. Highly sophisticated organizational networks and strategic decision making centers must exist. Operational procedures must be well established and effective. A high level of technology and substantial capital investment is required.

The mastery of even the smallest irrigation system is not a simple undertaking. However, a mastery of the world's largest continuous irrigation system, that located in West Pakistan, almost defies human comprehension. There are over 28 million acres of land under cultivation which are provided irrigation water by nearly 30,000 miles of canals and water delivery conveyances. Its modern irrigation works date back a century and its irrigation techniques, such as design of regime channels, weirs or permeable foundations, automatic distribution of water through modules, and operating procedures are truly unique. The Indus Basin Project, now in its final stages of completion, is the largest irrigation endeavor in the world, and may never possibly again be equalled.

These considerations alone make any investigation of West Pakistan's irrigated agriculture, indeed, a "humbling" experience.

As remarkable as may be the achievements in the development of West Pakistan's irrigated agriculture, the old serious problems have not yet been resolved. Each year thousands of acres of once productive land are being lost to the ancient problems of salinity and waterlogging. Agricultural productivity, although recently experiencing remarkable increases, still remains deplorably low. In spite of 75 per cent or more of its national labor force devoted to agriculture and sizeable amounts of capital investments, West Pakistan scarcely produces enough food to feed its rapidly growing population.

No easy solutions are available to bring about substantial increases in agricultural productivity. The so-called miracle seeds offer hope that remarkable increases of yields with certain small grain crops are

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[1]Max F. Millikan and David Hapgood, No Easy Harvest: The Dilemma of Agriculture in Underdeveloped Countries (Boston, Massachusetts: Little, Brown and Co., 1967), 37.

possible. However, the "Green Revolution" strongly indicates that much more than "seeds" are required. The critical aspect is the "right amount of water at the right time" in the plant's growing cycle; and virtually little is known about this relationship.[2]

The delivery of irrigation water constitutes complicated and intricate interaction processes between the natural, technological, and human and institutional factors. An irrigation system is more than engineering design and technology. Successful irrigated agriculture is a complex socio-technical system that is harmoniously operating within its natural environment. In organizational terms this requires close and complex interrelationships between the principal components of structure, technology, tasks, and people.[3]

Structure refers to the system of communication, authority, and superior-subordinate relationships.

Technology embraces the technical tools, facilities, and work processes and procedures.

Tasks are the role behavior of organizational members as assigned to the organization and to achieve its goals.

People are the organization's members,[4] their social behaviors in the work situation, and their attitudes, values, beliefs, and personal goals which influence their organizational behaviors.

How these components function together in the complex socio-technical system of irrigated agriculture have scarcely been investigated, and this relationship is certainly not very well understood -- Pakistan being no exception.

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[2]One of the best treatises on this subject is by P. J. Salter and J. E. Goode, Crop Responses to Water at Different Stages of Growth (Farnham Royal, Bucks, England: Commonwealth Agricultural Bureaux, 1967).

[3]This breakdown is derived from Harold J. Leavitt as found in his "Applied Organizational Change in Industry: Structural, Technical, and Human Approaches," in William W. Cooper, Harold J. Leavitt, and Maynard W. Shelly II (eds.), New Perspectives in Organizational Research (New York: John Wiley and Sons, 1964), 53-71 and Managerial Psychology (Chicago: University of Chicago Press, 1968).

[4]This can be a confusing problem in organizational analysis. See especially Peter W. Blau and W. Richard Scott, Formal Organizations: A Comparative Approach (San Francisco: Chandler Publications, 1962).

Even a casual investigation will reveal irrigation is usually a highly inefficient operation. The common situation is 50 per cent loss of water from the head to the farm field and another 50 per cent loss in the farm's water laterals and networks. Thus, at the most only 25 per cent of the water is used by the crop.[5]

Although considerable research is required for the entire field of irrigated agriculture, probably the greatest need is in the area of the human and institutional factors. It should never be forgotten that the critical component is the social organization's capacity to mobilize scarce resources to secure social ends. Resources are simply and comprehensively defined as "available means."[6] Man identifies and places these "means" to work to satisfy his needs. This requires ingenious institutions and organizational arrangements.

Technology by itself can accomplish nothing. Historically, many an irrigation system has collapsed because of a breakdown in its social organization. The required technology existed, but the human will and organization were inadequate.[7]

Unfortunately, too much of irrigation development represents the triumph of the technical over the purpose. In other words, the problem has been conceived almost entirely within the terms of engineering and agronomic design. The institutional and human factors have been scarcely considered and usually as an after thought as a consequence of system inadequacies.[8]

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[5]A well-known Indian study places the water losses as follows: an average of 47 percent of the water entering at the head is lost before reaching the farmers' fields, with 20 percent lost in the main canals and branches, 6 percent lost in the distributaries, and 21 percent lost in the watercourses. Another 20 to 25 percent loss occurs because of poor irrigation practices. See D. V. Joglekar, Irrigation Research in India (New Delhi: Central Board of Irrigation and Power, N.D.), 56.

[6]This definition is derived from Edgar S. Dunn, Jr., Economic and Social Development, A Process of Social Learning (Baltimore: Published for the Resources for the Future, Inc., by the Johns Hopkins Press, 1971), 305 et seq.

[7]This is a much discussed topic in the irrigation literature. See N. D. Gulhati and William Charles Smith, "Irrigated Agriculture: An Historical Review," in Robert M. Hagan, Howard R. Haise, and Talcott W. Edminster (eds.), Irrigation of Agriculture Lands (Madison, Wisconsin: American Society for Agronomy, 1967), 3-11.

[8]See Paul D. Marr, "The Social Context of Irrigation," in Hagan, Haise, and Edminster (eds.), Irrigation of Agriculture Lands, 1967, 12-22.

Without becoming involved with the reasons why this widespread situation prevails, the simple fact is that irrigated societies have attracted the attention of only a few social science scholars, as indicated in the two bibliographies of this document. Little sustained and erudite research has occurred.

Thus, a study of Pakistan's rich irrigation history takes on added importance. Undoubtedly, buried in its irrigation organization and practices are valuable lessons for other irrigation societies. The tremendous irrigation developments of West Pakistan cover a wide variety of situations and problems. West Pakistan presents an unusual research opportunity as well as a remarkable laboratory for training and experiments. Solutions to Pakistan's irrigation problems will have importance for nearly every other irrigation economy. To the extent which Pakistan resolves its human, institutional, and technological problems, these will serve elsewhere as constructive models of planned development and change in irrigated societies.

One lesson is clear out of the last 25 years of development assistance. Much of the required knowledge, technology, and institutional organization to implement planned development does not exist. Considerable fundamental research is required to provide the solutions for unique and urgent social problems.

For agriculture, this becomes even more distressing when it is realized that, as observed by Messrs. Fireman and Greeman, the:

> ...current research everywhere in the fields of soils, crops, and water use commonly is directed toward the solution of the more theoretical and intellectually satisfying problems that are of particular interest to the more advanced countries. ...(these research) findings ordinarily are not or cannot be translated into timely field practices useful in the solution of the manifold...problems faced by the vast majority of the cultivators throughout the world.[9]

They go on to add that more is being learned about such:

> erudite subjects as evapotranspiration or the laws governing water movement in unsaturated soils, while effective research on management factors such as conveyance and field losses, infiltration and drainage rates under less than ideal conditions...is virtually non-existent.[10]

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[9] Milton Fireman and David W. Greeman, "Water Management -- The Critical Element in Modern Irrigated Agriculture," in Essential Elements Necessary for Successful Irrigated Agriculture, Tipton Special Session (New Delhi: International Commission on Irrigation and Drainage, 1969), 212.

[10] Ibid.

The current research is important to the well-developed agricultural regions but little is of use to help solve the "critical but relatively crude production problems of the low-producing and developing areas."[11]

Speaking about the institutional framework, Messrs. Fireman and Greeman write: "...the root cause of unsuccessful irrigation development commonly is high-level mismanagement of the water resource. High level in the sense that the cultivators are not involved in the decisions that are made and are powerless to amend or override them."[12] They then go on to list a number of examples of mismanagement; one of which they underscore is the lack of support for a broad research program on problems of water management.

The conclusion that can be drawn from these remarks is that the developing countries will have to undertake increasingly research on irrigated agriculture that fits their own peculiar problems. The most critical problem is the management of the water at the cultivator level. Simple technical solutions are insufficient. A broad gaged interdisciplinary research program, drawing from many specialties, is required. To carry out this kind of meaningful research, the U.S. Agency for International Development is now assisting in the establishment of a number of "research centers of excellence" on irrigation water management in the semi-arid and subhumid regions of the world. A collaborative-type research program is being followed where American and host country researchers work together side-by-side. The objective is that these research findings will not only assist in resolving "site specific" problems in a particular country but can be applied as well elsewhere. The so-called "miracle seed" which initiated the "Green Revolution" is the ideal and the centers of excellence that developed these seeds serve as the model.

In Pakistan such a cooperative effort, with Colorado State University representing the U.S. component, is now getting underway. Colorado State University has a rich tradition in water management. Many of its faculty have had first hand experience in Pakistan and a large number of Pakistani officials and researchers have studied at or visited its campus. The probabilities of a mutually enriching experience between Colorado State University and appropriate associate Pakistani institutions such as the West Pakistan Agricultural University are indeed very high. This relationship represents truly a new venture in international cooperation and development. Our hope is that those associated with this pioneer experiment shall set a new constructive pattern of international cooperative relationships and in so doing make a significant contribution to the eradication of one of mankind's most ancient enemies, hunger.

Prepared by
Garth N. Jones

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[11] Ibid.

[12] Ibid., 213.

INFORMATIONAL SOURCES FOR WATER MANAGEMENT FOR AGRICULTURAL PRODUCTION IN PAKISTAN: WITH SPECIAL REFERENCE TO INSTITUTIONAL AND HUMAN FACTORS

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SUPPLY AND USE OF IRRIGATION WATER IN PAKISTAN

Part I

1.

SUPPLY AND USE OF IRRIGATION WATER IN PAKISTAN

Productive rainfed agriculture is not possible in the semi-arid conditions that exist in most of West Pakistan. Increases in agricultural production over the last one hundred years have been primarily dependent on the providing of additional irrigation water. As shown in Table 1.1, this will probably continue as the principal factor for future agricultural expansion because of a sizeable water development potential.

This water supply potential can be realized in three ways: (1) by the exploitation of the usable ground water which underlies a large part of the Indus Plains, (2) by the development of reservoir facilities which will store surplus kharif water which flows to the Arabian Sea,[1] and (3) by the enlargement of the canals to handle greater diversion of kharif river flows.[2]

A. Water and Land Resources

Physiography

West Pakistan lies between the longitudes 61° East to 76° East and between latitudes 23° North to 37° North. Excluding Indian occupied Kashmir, the total area of West Pakistan is 310,400 square miles or 803,932 km^2. Great varieties of landscape are found, ranging from the snow-covered peaks of the great Himalayan and Karakoram mountains to the north to the hot, dry desert of the Sind in the south.

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[1]According to I. D. Carruthers, Irrigation Development Planning, Aspects of Pakistan Experience (Ashford, Kent, U.K.: Economics Department, Wye College, 1968), on page 11 that two-thirds of the kharif river discharge passes unused to the sea.

[2]See Pieter Lieftinck, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources of West Pakistan, A Study in Sector Planning (Baltimore: The Johns Hopkins Press, 1969), volume 11, 63.

Table 1.1

Development of Irrigation Supplies from 1965 to 2000*

	Million Acre Feet				
	1965	1975	1985	2000	Percentage Increase
Rainfall	6	7	9	10	
Surface Water	58	63	77	91	50
Groundwater	10	30	40	44	340

*Adapted from Pieter Lieftinck, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources of West Pakistan, A Study in Sector Planning (Baltimore: The Johns Hopkins Press, 1969), volume 11, 63.

Out of an area of 199 million acres or 80.53 million hectares, excluding the territory of Indian occupied Kashmir, 39 million acres or 15.78 million hectares are cultivated. The cultivated area comprises approximately 20 percent of the total area of West Pakistan. The largest part of the cultivated area is found in the Indus Basin which consists of 131 million acres or 53 million hectares. The total cultivable area approaches 75 million acres or 30.35 hectares. Presently, 29 million acres or 11.74 million hectares are under irrigation. The present agricultural land use is shown in Table 1.2.

Climate and Rainfall

The regional conditions in West Pakistan range from arid to semi-arid. The summer months between May to August are extremely hot with high temperatures over much of the Indus Plains usually in the neighborhood of 38°C to 40°C or 100°F to 104°F. Temperatures reaching 49°C or 120°F are not uncommon. A temperature of 53°C or 127°F has been recorded at Jacobabad in the upper Sind which ranks among the world's highest. In the mountain regions of the north, the summers are generally cool, the temperatures appreciably varying with the elevation and other factors. The plains regions frequently experience a unique phenomenon of dust storms which are usually followed by thunder showers. The winter months are fairly cool during the months of December and January with the daytime temperatures in the neighborhood of 20°C or 68°F and the evening time temperatures between 2.2°C to 5°C or 36°F to 41°F. Sometimes the freezing point is reached. The climate along the coastal areas of the Arabian Sea is not quite as hot in the summer and is milder in the winter.

West Pakistan has a monsoon climate, with two seasons of rainfall. The summer monsoon is from June to September and the winter monsoon from December to March. The rainfall varies substantially from 889 mm or 35 inches in the sub-mountain regions in the north to about 127 mm or 5 inches in the arid regions of the Sind and Baluchistan in the south.

Population and Size of Land Holdings

Population. The present population of West Pakistan in 1971 is estimated to be 62 million and is growing annually at the rate of 2.5 to 2.7 percent.[3]

The rural population is from 70 to 75 per cent and is projected to rapidly decline over the next 20 years. The Planning Commission projects

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[3]This figure is derived from the population projections found in S. A. Abbas, Supply and Demand of Selected Agricultural Products in Pakistan, 1961-1975 (Karachi: Oxford University Press), chapter 4.

Table 1.2

Agricultural Land Use in West Pakistan*

Present Use	Land Use (million) Hectares	Acres	Percent
Culturable Commanded Area (CCA)			
Suitable for Perennial Irrigation	8.22	20.3	
Suitable for Non-Perennial Irrigation	5.34	13.2	
Total	13.56	33.5	16.8
Other Cultivated Area			
Irrigation: Wells, Streams, Tanks, Etc.	0.65	1.6	
Rainfed (Barani)	4.05	10.0	
Riverain	1.17	2.9	
Total	5.87	14.5	7.3
Culturable Waste and Forest			
Culturable Waste	9.71	24.0	
Forest Land (Estimated)	1.21	3.0	
Total	10.92	27.0	13.6
Total Suitable for Agriculture and Forestry	30.35	75.0	37.7
Unsuitable for Agriculture and Forestry			
Mountains and Deserts	39.66	98.0	
Unrecorded towns, water areas, etc.	10.52	26.0	
Total	50.18	124.0	62.3
Total Area - West Pakistan	80.53	199.0	100

*Adapted from K. K. Framji and I. K. Mahajan, Irrigation and Drainage in the World (New Delhi, India: International Commission on Irrigation and Drainage, 1969), volume 11, 791-92.

by 1985 the population breakdown will be 55 percent rural and 45 percent urban.[4] As shown in Figure 1.1, the population densities closely follow the profile of the Indus rivers and gives a reasonable picture of the wide disparity in the capacity of the land to support people.

Apart from the Karachi area where high population density is largely a result of commercial and industrial functions, the regional densities reflect rather accurately the intensity of agricultural settlement. High population densities of over 500 per square mile extends from the sub-Himalayan regions of Rujrat to Sialkot (a region where well irrigation supplements a fairly good rainfall) into the canal irrigated plains of the Punjab (as far as the Lyallpur and Sahiwal, formerly Montgomery, regions). A region of moderately high population density, 250 to 500, flanks the high density zone, completing the apex of the Punjab irrigated districts in Multan.

To the north of the Punjab plains, regions from moderate to high population density are found. In the Rawalpindi region the population density is over 500 persons per square mile. The regions of Peshawar and Mardan within the Vale of Peshawar have high population densites associated with their agricultural development. These two regions are bordered by harsh mountain environments which have surprisingly high population densities where the tribal peoples are heavily concentrated in a few patches of productive land in the valleys and intermountain basins, namely Khyber and Mohmand.

Population densities in the average of 138 per square mile are found in the continuous belt extending south from the Himalayan foothill regions (Dir, Kalam, Swat, and Hazara) through the Potwar Plateau (Campbellpore) and Kohat-Bannu regions on either side of the Indus and onto the Indus Plains in Dera Ismail Khan and Mianwali. In the more arid regions to the south moderate population densities are only found in the irrigated zones of the Indus. Downstream from the Sukkur Barrage in Hyderabad the density exceeds 250 persons per square mile. Away from the irrigated regions, population densites are small, varying from 26 to 100 persons per square mile.

Size of Land Holdings. The pattern of rural settlement is generally nucleated. The need to master the control of water has undoubtedly contributed to this tendency, but even in the Punjab canal colonies nucleation is the rule. The canal colonies are readily distinguishable from the traditional settlements by their more standardized form, in the post office guide on the topographical map, by their codified addresses, each village having a number rather than a name which links it to the canal system which delivers its water.[5]

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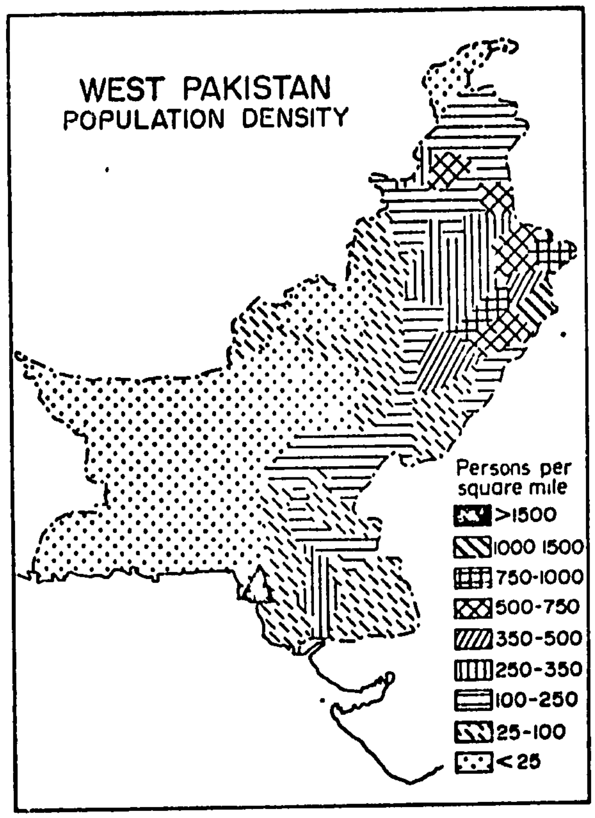
[4]See Mahdi Hasan, "Introductory Address," in Garth N. Jones and Shafik H. Hashmi (eds.), Problems of Urbanization in Pakistan, Proceedings of A Conference (Karachi: National Institute of Public Administration, 1967), 6.

[5]See Sir Malcolm Darling, The Punjab Peasant in Prosperity and Debt (London: Oxford University Press, 1947), especially chapter 7.

Figure 1.1

West Pakistan: population distribution*



*Taken from B. L. C. Johnson, <u>South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon</u> (London: Heinemann Educational Books, Ltd., 1969), 107.

Of the cropped area of 39 million acres or 15.78 million hectares, 70 percent lies within the canal irrigated areas of the Indus plains system. This system commands a culturable area of 33 million acres or 13.35 million hectares. Each year usually 29 million acres or 11.74 million hectares receive irrigation supplies.

As shown in Table 1.3, the land holdings in West Pakistan vary greatly in size. A representative farm falls between 15 to 35 acres.[6]

The agricultural land holdings are highly fragmented which greatly complicates the productive process. In recent years a land consolidation program has been initiated.[7]

Soils and Landforms

In the present and potential irrigated lands, as shown in Figure 1.2, the soils are predominantly of an alluvial origin and are found in the piedmonts and the flood plains. The Indus plain is an alluvial area stretching 800 miles or 1,287 kilometers and varies in width from 100 miles or 161 kilometers to 350 miles or 563 kilometers.

The physical properties of the soil are generally favorable for high irrigated agricultural production. However, sometimes for the heavier textured soils there occurs the formation of a crust layer which restricts water infiltration and hence plant growth. This appears to be the result of fine silt and weakly formed soil structure in the top layers along with the shortage of organic materials in the soil.

The soils of the Indus plains are often deficient in nitrogen and organic matter, and in many cases phosphate as well. No widespread deficiency of trace elements appears evident.

Salinity and waterlogging constitute a major problem through most of Pakistan's irrigated lands. These problems are aggravated by the common practice of under-irrigation and "leaky" canals.[8] It is estimated that a third of West Pakistan's irrigated lands is effected by salinity and each year thousands of acres of once productive land are lost.

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[6]For a fuller discussion see Hamza A. Alavi, "Structure of the Agrarian Economy in West Pakistan and Development Strategy," Pakistan Administrative Staff College Quarterly, 6(September, December, 1968), 57-75.

[7]See particularly S. M. Rizvi, M. A. Sabzwari, and C. M. Sharif, Consolidation of Holdings (Peshawar: Pakistan Academy for Rural Development, 1965).

[8]See Garth N. Jones and Raymond L. Anderson, The Problem of Under-Irrigation in West Pakistan: Research Studies and Needs, Water Management Technical Report No. 8 (Fort Collins: Cususwash Project, Colorado State University, 1970).

Table 1.3

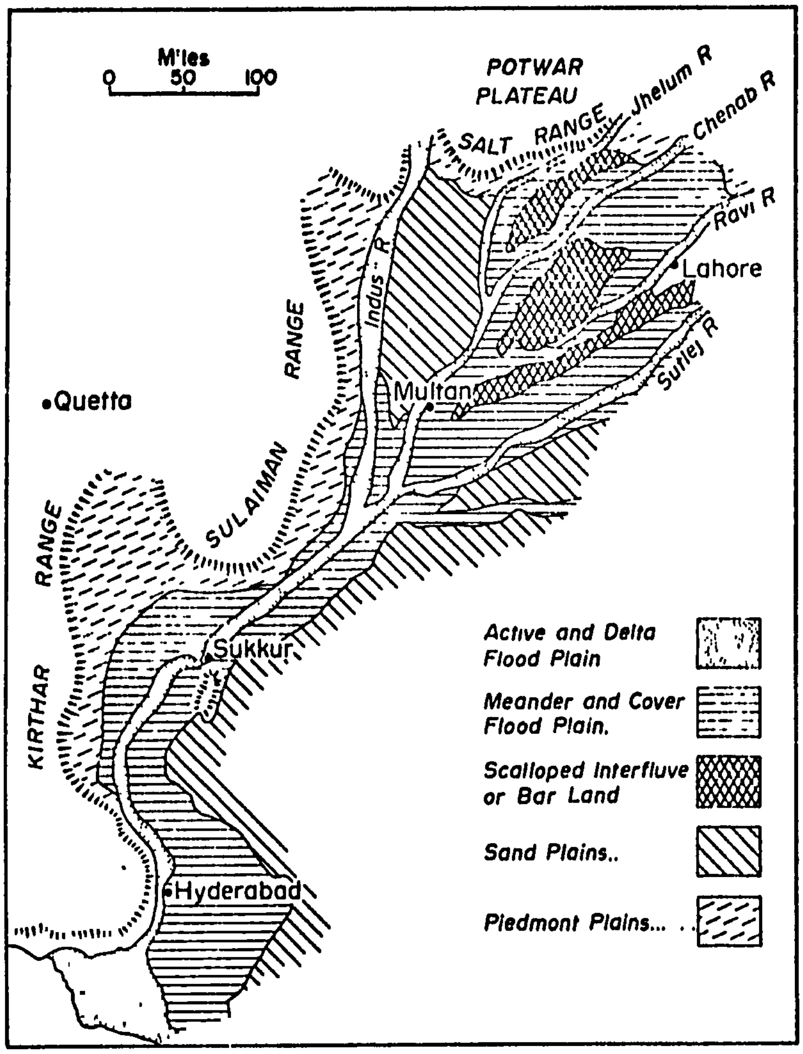
Number and Size of Farms in West Pakistan in 1961*

Farm Size	Number of Farms	Total Area
	(Percentage of Total)	(Percentage of Total)
Small Farms, under 5 acres	49%	9%
Medium Farms, 5 to 55 acres	43%	48%
Large Farms, 25 acres or more	8%	43%

*Census of Agriculture, 1960 (Karachi: Government Press, 1961), report 2, table III.

Figure 1.2

West Pakistan: landforms of Indus Plains*



*Taken from B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon (London: Heinemann Educational Books, Ltd., 1969), 98.

Patterns of Land Use

Crops. The crops are grouped into two categories: (1) rabi (winter) and (2) kharif (summer). Table 1.4 shows the areas planted and percentages of the total by each of the main crops in the major regions of the Indus plains.

Of the rabi crops, cereals, wheat and to a lesser extent barley, are the most important. Gram and other pulses provide an important protein source to the Pakistani diet. Vegetable oils are supplied by rape-seed, colza, and rocket crops which are sometimes also used as green fodder. Clover is the main rabi fodder crop. Tobacco is cultivated in some areas, notably the Peshawar Vale as a cash crop.

The kharif crops are more varied. Millets, particularly bajra, are grown on lands where irrigation water is unreliable or absent. Great Millet or jowar and bajra are extensively grown as irrigated crops. Rue is grown in the Hyderabad region. Maize is grown in the northern regions and is used both as a fodder and as a food. Cotton, mostly the American long-stapled variety is widely grown. Sugar cane is another crop and is extensively grown in the Vale of Peshawar, and in the Gujrat and Sialkot regions. Although normally grown as a kharif crop, sugar cane requires a long growing season which may extend into the rabi season.

Agricultural Regions. The broad regions of agricultural differentiation in the Indus plains is shown in Figure 1.3. The economically less important agricultural regions generally lie outside of the Indus plains and comprise a wide range of conditions which is discussed in later sections.

Water Resources

Surface Waters. The rain contribution to crops in the canal commanded areas is estimated to be in the neighborhood of 6 million acre feet or 7,400.88 million m^3. This could be increased, because of expansion of the irrigated commands, to about 10 million acre feet or 12,334.8 million m^3.

The Indus River and each of its five tributaries (the Kabul, the Jhelum, the Chenab, the Ravi and the Sutlej) have individual flow characteristics, but they all rise in the spring and early summer months with the snowmelt and monsoon rainfall and have a combined peak discharge in July or August. In the winter months the river flows are much lower and during the months of November to February the mean monthly flows are about one-tenth of those in the summer months.

The mean annual discharge of the Indus plains' rivers is in the neighborhood of 167 million acre feet or 205,991 million m^3. Approximately 79 million acre feet or 97,444.9 m^3 are diverted into the canal system and some 76 million acre feet or 93,744.5 m^3 is discharged into the Arabian Sea. The remaining amount of water is lost because of evaporation and

Table 1.4*

Percentage of seasonally cropped area under main crops. Note the relative importance of rabi and kharif cropping in each region as indicated by the total area of crops at each season.

(Source: Colombo Plan data)

RABI CROPS

Divisions	Cereals	Pulses	Cereals-pulses mixed	Oil-seeds	Tobacco	Vegetables	Fruits	Fodder	(Area -- million acres)
Peshawar, Dera Ismail Khan	67	16	--	4.5	1.5	2	0.5	7.5	1.2
Rawalpindi, Lahore, Sargodha, Multan	61	15.5	3	4	0.5	1.5	0.5	13.5	11.19
Bahawalpur	55	19.5	6	9	--	2.5	--	7	1.32
Khairpur (1)	54.5	10	--	31	--	0.5	--	--	0.24
Sind (2)	50	32.5	--	12	--	--	1.0	3.5	2.46
Baluchistan (3)	57	12.5	--	28	--	--	--	--	0.15
INDUS PLAINS	60	19	2.5	6.5	0.5	1	0.5	10.5	16.56 (100 percent)

Notes: (1) The former Punjab state of Khairpur now incorporated in a larger division of the same name.
(2) Comprising Hyderabad Division and Sukkur District, the latter now part of Khairpur Division.
(3) Only a part of the lowland area round Sibi is accounted for here.

*Taken from B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon (London: Heinemann Educational Books, Ltd., 1969), 96.

Table 1.4 (continued)

(Source: Colombo Plan data)

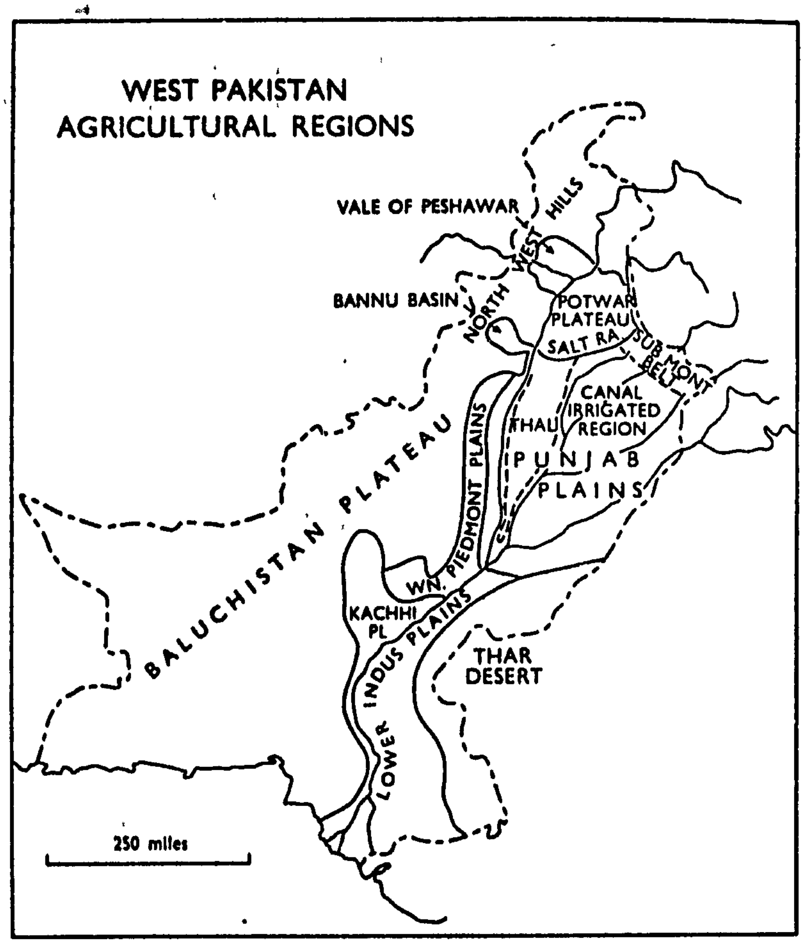
KHARIF CROPS

Divisions	Rice	Millets	Maize	Pulses	Oil-seeds	Cotton	Sugar-cane	Vegetables	Fruits	Fodder	(Area -- million acres)
Peshawar, Dera Ismail Khan	2	19.5	44.5	2.5	0.5	2	23.5	1.5	1	3	0.5
Rawalpindi, Lahore, Sargodha, Multan	12.5	26.5	6.5	5.0	0.5	22	7	2	0.5	15.5	7.25
Bahawalpur	5	31.5	2.5	14.5	6	20.5	7	1	0.5	10	1.17
Khairpur (1)	10	32.5	--	1	--	30	4.5	0.5	4.5	17	0.18
Sind (2)	45.5	24.5	--	0.5	0.5	23	0.5	0.5	1	2	3.25
Baluchistan (3)	41.5	50.5	--	--	--	--	--	--	8	--	0.17
INDUS PLAINS	20	27	6	4.5	1	21	6	1.5	0.5	11	12.55 (100 percent)

Notes: (1) The former Punjab state of Khairpur now incorporated in a larger division of the same name.
(2) Comprising Hyderabad Division and Sukkur District, the latter now part of Khairpur Division.
(3) Only a part of the lowland area round Sibi is accounted for here.

Figure 1.3

West Pakistan: agricultural regions*



*Taken from B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon (London: Heinemann Educational Books, Ltd., 1969), 97.

seepage. The discharge to the sea largely takes place in the summer months, between June and September when most of the canals are being operated at full capacity.

After the complete implementation of the Indus Waters Treaty in the early 1970's, India will be entitled to divert all the flows of the two eastern rivers, the Ravi and the Sutlej, for its own use. These two rivers have a combined average discharge of 33 million acre feet or 40,704.8 million m^3 of which approximately 25 million acre feet or 30,837 m^3 flow into West Pakistan. This flow of 25 million acre feet will be subtracted from the present mean of 167 million acre feet which leaves for West Pakistan a future mean supply of approximately 142 million acre feet. The River flow breakdown for West Pakistan is shown below.

River	Mean Annual Discharge 1922-62	
	Million m^3	Million acre feet
Indus (including the Kabul)	114,714	93
Jhelum	28,370	23
Chenab	32,070	26
	175,154	142

The medium combined flow, exceeded in 50% of the years under record, of these three rivers is slightly less than the mean, i.e., 140 million acre feet or 172,687 million m^3. The lowest combined flow on record is 116 million acre feet or 143,084 million m^3.

The flow pattern of the Indus River is more stable than either those of the Jhelum or the Chenab. All these rivers carry large quantities of silt with a sediment transport estimated at 700 million short tons or a volume of 0.4 million acre feet.

Ground Waters. The deep alluvial deposits of the Indus plains form an extensive ground water aquifer which has a tremendous development potential. Before the development of the Indus irrigation system, the groundwater table was well below the surface and the aquifer in a state of hydrological equilibrium. The annual recharge to the aquifer from the rivers and rainfall was probably in the neighborhood of 10 million acre feet or 12,334.8 million m^3. Today the recharge is three or four times as much as that of the natural state with the result that the water table has risen to ten feet of the surface in over 50 percent of the canal commanded areas and to five feet in about 15 percent of these areas. About two million acres are seriously damaged by salinity and waterlogging.

Outside of the Indus plains little is known about the groundwater potential. The potential groundwater suppl is estimated to reach an annual 45 million acre feet or 55,506.6 million m^3.

B. Irrigation Development and Plans

Basic Irrigation Statistics

Basic statistics on irrigation in West Pakistan are presented below.[9]

Area Cultivated (net)	Million hectares	Million acres
Area cultivated (net) in 1947-1948	14.69	36.30
Area cultivated (net) in 1958-1959	16.55	40.90
Area cultivated (net) in 1966-1967	19.69	48.66

Area Irrigated by Sources		Hectares	Acres
Year	Source		
1900	Government Canals	1,720,000	4,250,000
	Wells and others	860,000	2,125,000
	Total	2,580,000	6,375,000
1947-1948	Government Canals	7,787,520	19,243,375
	Private Canals	197,490	488,000
	Tanks	16,200	40,000
	Wells	972,060	2,402,000
	Tubewells	Nil	Nil
	Other Sources	464,600	1,148,000
	Total	9,437,870	23,321,375
1958-1959	Government Canals	8,462,380	20,911,000
	Private Canals	199,915	494,000
	Tanks	59,085	146,000
	Wells	77,820	192,300
	Tubewells	122,620	303,000
	Other Sources	624,430	1,543,000
	Total	11,398,370	28,166,000

[9] This statistical data is drawn from K. K. Framji and I. K. Mahajan, Irrigation and Drainage in the World (New Delhi: International Commission on Irrigation and Drainage, 1969), volume 11, 809-12.

1965-1966	Government Canals	8,370,920	20,685,000
	Private Canals	250,905	620,000
	Tanks	9,710	24,000
	Wells	957,490	2,366,000
	Tubewells	797,230	1,970,000
	Other Sources	1,012,115	2,501,000
	Total	11,398,370	23,166,000

Length of Irrigation Canals	km	Miles
Length of Government canals	59,085	36,714
Length of inter-river link canals	663	412

Capital cost per unit in Pakistan	Hectares	Acres
Capital cost before 1900	39.54	16.00
Capital cost in 1958-1959	185.33	75.00
Capital cost in 1965-1966	271.82	110.00

Operation and maintenance cost per unit	Hectares	Acres
In 1900 (northern area only)	2.87	1.16
In 1958-1959	9.09	3.68
In 1965-1966	12.03	4.87

Area drained	Hectares	Acres
Area drained	6,086,470	15,040,000

Length of drains	km	Miles
Length (including those constructed in G. M. Barrage area ending 1967-1968)	8,534.35	5,303

Capital Cost per unit drained	Hectares	Acres
Cost	118.61	48

Operation and maintenance cost per unit drained	Hectares	Acres
Cost	Rs. 4.94	Rs. 2.0

Irrigation Development: Early Period

Irrigation along the natural inundation of the Indus River has been practices for over 5,000 years. As early as the 8th century, artificial inundation was utilized by digging new channels to provide water at considerable distances from the rivers. By the 18th century, an extensive network of canals had been constructed in the narrow belts along the Indus River and its tributaries.

During the first half of the 19th century considerable improvement and expansion of the inundation canals occurred. Because of the 1878 famine, the British Indian government constructed four major inundation canals: (1) the Lower Inundation System, (2) the Sidhonai, (3) the Lower Sohag, and (4) Para Canals and the Ramnagar Canal.[10]

The Ramnagar canal, which was completed in 1887 and designed to irrigate an area of 144,000 acres, proved initially to be a failure. In 1890 a weir on the Chenab River near the head of the Ramnagar canal at Khanki was constructed and the canal capacity subsequently doubled. The project became a success and now provides perennial irrigation to approximately three million acres. It has a delivery capacity of 11,727 cusec or 332 m^3/s.

The Lower Swat Canal was opened in 1884-85 and the Kabul River Canal in 1896-97. At the end of the 19th century approximately 9.5 million acres of 3.8 million hectares of land were under irrigation: (1) 4.25 million acres under canal command and (2) 5.25 million acres under wells and other means.

Irrigation Development: An Integrated System[11]

At the turn of the 20th century the British Indian government embarked upon a tremendous program, as largely depicted in Figure 1.4, to construct an integrated irrigation system which would eventually command over 30 million acres. The major projects will now be briefly described.

The Lower Jhelum Canal Project, started in 1898, was completed in 1901. The Shahpur Inundation Canals with a culturable area of 101,200 hectares or 250,000 acres in 1951-52 was merged with this project. The Canal has full supply discharge of 147 m^3/x or 5,200 cusec. It composes about 322 km or 200 miles of canals and branches and about 1,609 km or 1,000 miles of distributaries, commanding an area of about 607,000 hectares or 1.5 million acres.

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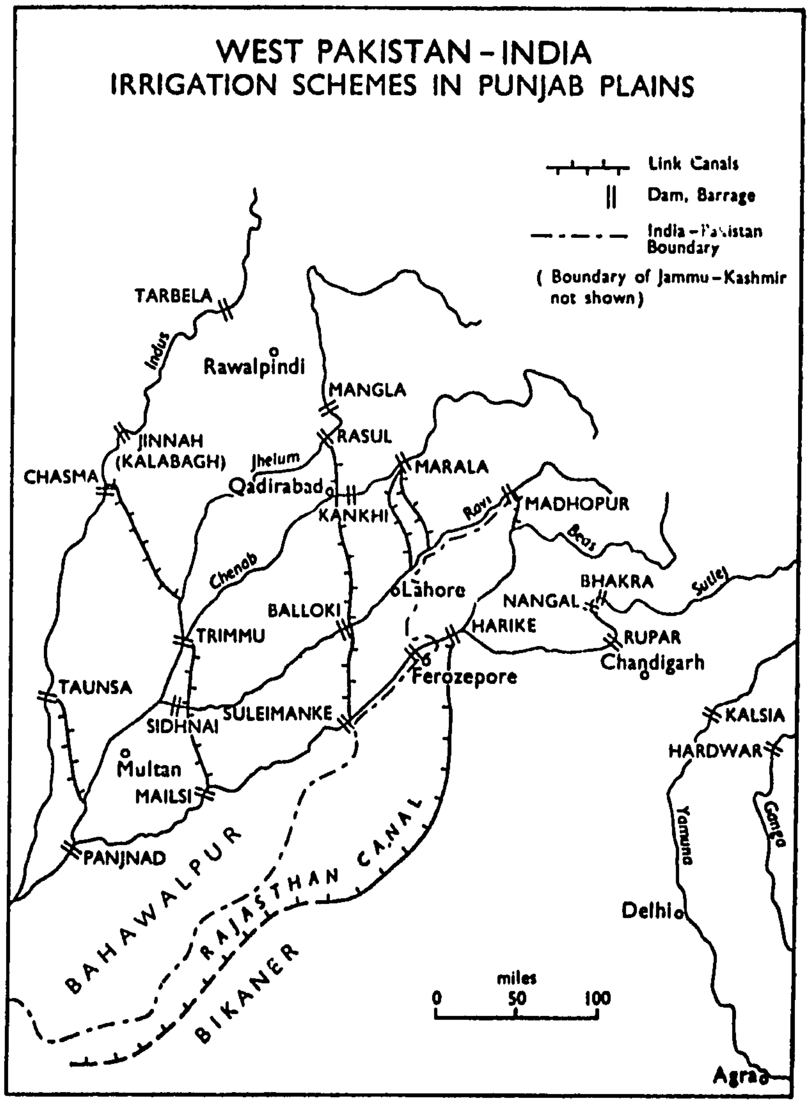
[10] An excellent historical treatment is found in Aloys Arthur Michel, The Indus Rivers, A Study of the Effects of Partition (New Haven: Yale University Press, 1967), particularly Chapter 3.

[11] This section builds largely upon Michel, The Indus Rivers, 1967, especially Chapters 3 and 4, and K. K. Framji and I. K. Mahajan, Irrigation and Drainage in the World, 1969, especially volume 11, 809 et seq.

Figure 1.4

West Pakistan-India: irrigation schemes in Punjab Plains*



*Taken from B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon (London: Heinemann Educational Books, Ltd., 1969), 104.

The Irrigation Commission report of 1903 led to a trans-basin development known as "The Triple Canal Project." This project, initiated in 1905, transfers the waters of the Jhelum across the Chenab and the Ravi Rivers for irrigating the wastelands south of the Ravi. The surplus water of the Jhelum River is carried by the Upper Jhelum Canal, taking off at Mangla to the Chenab River at Khanki to feed the Lower Chenab Canal. The Mangla headworks is a natural offtake, taking advantage of the shingle bar in the Jhelum River downstream.

The Upper Jhelum Canal was considered a major engineering feat, since it has a large number of major level crossings and cross drainage works. The excess potential made available in the Chenab River was diverted at Marala Weir into the upper Chenab Canals, which passed into the Ravi River a few miles upstream of Balloki where the headworks of the lower Bari Doab Canal is located. The Tripple Canal Project came into operation in 1912-15, and it ranks among the foremost inter-basin transfer irrigation schemes. The three canals have a total full supply discharge of 929 m^3/s or 32,813 cusec and command a culturable area of 1.4 million hectares or 3.45 million acres.

The Upper Swat Canal was completed in 1917-18 and the Upper Sind Unundation Canal System in 1921.

The Sutlej Valley Project, constructed between 1921 and 1932, comprises four barrages, one each at Ferozepor (now in India) and at Suleimanki, Islam-Panjnad in Pakistan, and 11 canals out of which two now lie in India and nine in West Pakistan. The total capacity of the nine canals in Pakistan is 1,210 m^3/s or 42,733 cusec. They command a total culturable area of 1.45 million hectares or 3.62 million acres.

The Haveli Canal Project, comprising a barrage at Trimmu at the confluence of the Chenab and the Jhelum, two main canals, the Haveli Canal on the left bank and the Rangput Canal on the right bank, was completed in 1939. The Trimmu Barrage was the first barrage designed as a flexible reinforced concrete raft in the sub-continent. The total culturable area served by the canals is 0.55 million hectares or 1.35 million acres.

The Sukkur Barrage Project, in the Sind, is the largest controlled irrigation scheme in the world. This project began operation in 1932. The new canals, seven in number merging in them a large number of old inundation canals in middle Sind, have an aggregate full supply discharge of 1,346 m^3/s or 47,530 cusec, and culturable commanded area of 3 million hectares or 7.5 million acres. At the time of its construction in 1923, the Sukkur Barrage was the largest in the world. The barrage consists of separate reinforced concrete arches for the gate bridge and roadway bridge on common piers. It has 66 bays each of 18.3 m or 60 feet clear span.

The second barrage to be constructed on the Indus was the Kalabagh Barrage (Jinnah Barrage). It was initiated in 1939 and opened in 1946.

In 1947, at the time of the nation's independence, the total irrigated land area of West Pakistan was 8,437,500 hectares or 20,843,375 acres. Of this total, 7,787,520 hectares or 19,243,375 acres was irrigated with canal water and 650,000 hectares or 1,600,000 acres was irrigated with stream, wells and tank water. All of the available surface flow supplies had been allocated to the Punjab, the Sind, and the States of undivided India. The supplies were shared according to the established uses. Soon after partition, however, a dispute arose between the East and West Punjab Governments regarding the supply by East Punjab of water to the Central Bari Doab and the Depalpur Canals in West Punjab. The claim of the East Punjab (India) Government was that under the Punjab Partition (Apportionment of Assets and Liabilities) Order of 1947 and the Arbitral Award, the proprietary rights in the waters of the rivers in East Punjab (India) was vested wholly in East Punjab Government (India) and that the West Punjab Government (Pakistan) could not claim any share of these waters. The West Punjab Government (Pakistan) contested this claim. Its view was that the point had conclusively been decided in its favor by implication in the Arbitral Award and that in accordance with international law and equity West Punjab had a right to the waters of the East Punjab rivers. On April 1, 1948 India cut off the supplies in all the canals which flowed from India to Pakistan. The East Punjab (India) later reopened the flow of water into these canals on certain conditions. This led subsequently to negotiations between the two countries under the good offices of the International Bank for Reconstruction and Development. After ten years of protracted discussions, in 1960, the Indus Water Treaty was concluded. And soon thereafter, the construction of a system of irrigation works under the Indus Basin Replacement Plan was initiated.

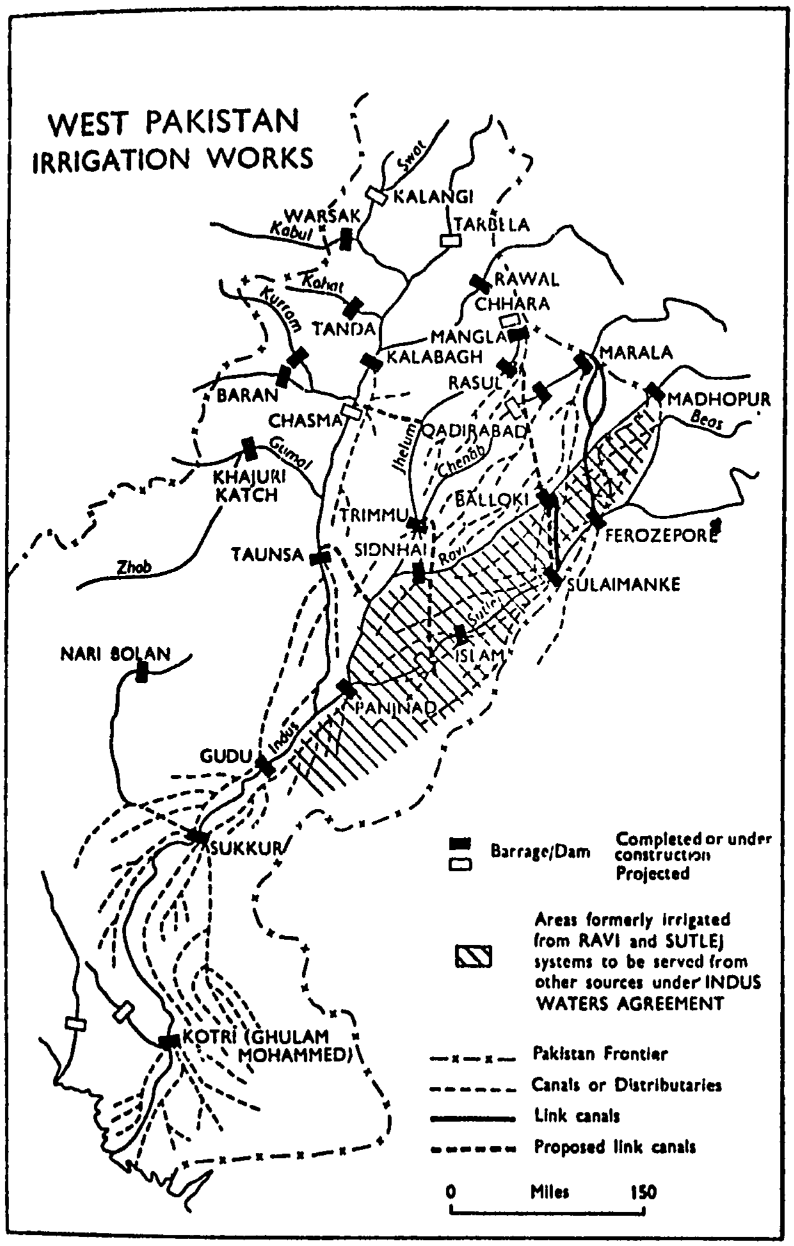
As shows in Figure 1.5, this system of works will replace from the Indus western rivers and other sources water needed for the irrigation canals in West Pakistan which, as of August 15, 1947, were largely dependent on water supplied from the Indus eastern rivers. The "replacement plan" essentially includes the construction of the Mangla Dam on the Jhelum, Tarbela Dam on the Indus, seven link canals, five barrages, a gated syphon, and the remodeling of several of the existing irrigation works.

After independence, the Lower Sind Inundation Canals were converted into a weir-controlled canals to command culturable area of 809,400 hectares or 2 million acres and to serve a local culturable commanded area of 1,133,120 hectares or 2.8 million acres. This design was completed with thb construction of the Ghulam Mohammad Barrage at Kotri (1947-55). Similarly, the Gudu Barrage built between 1953-1962 at the head of Upper Sind Inundation Canals System converted the Upper Sind Inundation Canals into a controlled perennial canals system for the irrigation of 1,133,120 hectares or 2.8 million acres.

The Taunsa Barrage constructed between 1953-1958 on the Indus provided weir-controlled irrigation supplies to a culturable commanded area of 687,970 hectares or 1.7 million acres. This is a multipurpose barrage which also provides bridges for a road and a railway as well as a head regulator for Taunsa-Panjnad Link canals.

Figure 1.5

West Pakistan: irrigation schemes*



*Taken from B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon (London: Heinemann Educational Books, Ltd., 1969), 103.

The Thal Project is an irrigation scheme for the Thal Area with its headworks, the Jinnah Barrage, at Kalabagh on the Indus River. The Thal Canal taking off from the Jinnah Barrage is designed to irrigate a commanded area of 878,575 hectares or 2,171,000 acres, including about 14,165 hectares or 35,000 acres of government land in the districts of Mianwali and Muzaffargarh. The present cultivable commanded area in the Thal project is 662,510 hectares or 1,637,103 acres. The main line upper canal is a lined channel with a capacity of 283 m^3/s or 10,000 cusec but its withdrawal has been restricted to 170 m^3/s or 6,000 cusec. The entire system is 3,148 km or 1956 miles in length. Although formally opened in 1946, irrigation water was not made available until May 1968. An area of 247,696 hectares or 1,138,124 acres were irrigated in 1967-68. The anticipated date of full development is 1979.

The Ghulam Mohammad Barrage Project comprises a barrage across the Indus River near Hyderabad, a feeder canal on the right bank, three off-taking canals on the left bank for the irrigation of 475,505 hectares or 1,175,000 acres which was previously served by the Fuleli and other inundation canals and 657,614 hectares or 1,625,000 acres of new area. The project was approved in 1947, principally with a view to counteracting the drops in river levels because of increased upstream withdrawals. The construction of the project was started in 1947 and the barrage was completed and opened in March 1955. The project canal system, with an aggregate diversion capacity of 1,169.5 m^3/s or 41,300 cusec, is now under construction and expected to be completed by 1990.

The Taunsa Barrage Project consists of a barrage with a road and railway bridge across the Indus River near Taunsa. The work on the barrage was started in 1953 and completed in 1958. Work on the Muzaffargarh Canal taking off on the left bank of the barrage was completed in 1959. The Dera Ghazi Khan Canal, taking off from the right bank, has also been completed. The barrage commands a culturable area of 539,863 hectares or 1,334,031 acres; of which the new area is 97,772 hectares or 241,600 acres. The capacity of Dera Ghazi Khan Canal is 219 m^3/s or 7,744 cusec and that of Muzaffargarh Canal is 232 m^3/s or 8,200 cusec.

The Guddu Barrage Project on the Indus River commands a culturable area of 1.08 million hectares or 2.68 million acres, including a new area of 228,566 hectares or 564,800 acres. The rest of the area is commanded by the existing inundation canals. There are three feeder canals. Of these one is called the Desert Pat Feeder to feed the existing Desert Canal and the proposed Pat Canal. The second one will be Bogari Sind Feeder which will feed all the existing and proposed canals. The third is called Ghotki Feeder to feed all the canals on the left bank.

The Desert Pat Feeder has a discharge capacity of 365 m^3/s or 12,900 cusec, the Bogari Sind Feeder 439 m^3/s or 15,500 cusec, and the Ghotki Feeder Canal 240.7 m^3/s or 8,500 cusec.

The Abbasia Canal Extension Project. Under the Sutlej Valley Project, the Punjab and Abbasia canals were constructed during 1927-1932. Because of the 1930's economic depression, however, the Bahawalpur Government found it difficult to undertake the necessary colonization work. On the advice of the Darley Committee, the Abbasia Canal was abandoned and its rabi water supplies were diverted to the P.W.D. canal area lying to the south of the Karachi-Lahore Railway line. The crown waste lands totaling 110,885 hectares or 274,000 acres in area, on the Abbasia canal command which was abandoned in 1932 could be brought under cultivation by the extension of this project.

In 1946-1951 the canal and the feeders were constructed and an area of about 52,610 hectares or 130,000 acres was opened up for irrigation.

The Warsak High Level Canal Project. The Warsak Dam on the Kabul River is situated 29 km or 18 miles northwest of Peshawar. The dam was completed in 1961 and consists of a gravity concrete dam 71.63 m or 235 feet high and 229 m or 750 feet long at the crest. The power house has been designed for six units of 40,000 kW. At present only four units have been installed. Apart from hydro-electric power generation, the dam feeds two canals, one on the right bank and another on the left bank. A tunnel of about 4.83 km or three miles long and 3.05 m or ten feet diameter on the right bank connects the right bank canal with the Warsak Reservoir. Another tunnel on the left 3.22 km or two miles long and 2.14 m or seven feet wide connects the left bank canal.

The total area commanded by these canals in the Peshawar district and tribal territory is 45,325 hectares or 112,000 acres. The canal on the right bank has a capacity of 14.16 m^3/s or 500 cusec which divides into two canals; one known as the gravity flow canal with a capacity of 6.37 m^3/s or 225 cusec and the other a lift canal with a capacity of 5.66 m^3/s or 200 cusec. The rising main from the electrically drive pump to the outfall is over 1.61 km or one mile long. The left bank canal has a capacity of 1.27 m^3/s or 45 cusec. The balance 2.12 m^3/s or 75 cusec has been left for future expansion of the canals. The project commenced in 1957 and the gravity flow canal was completed in 1961. The lift canal was recently completed. The net lift of 48.8 m or 160 feet and a gross lift of 60.96 m or 200 feet is the highest lift for such a discharge in the sub-continent.

The Kurram Ghari and Baran Dam Project. A weir on the Kurram River in Bannu district to give weir-controlled irrigation to 45,325 hectares or 112,000 acres was completed in the year 1955. The next phase of the project is the right bank canal. A dam on the Baran Nalah, a tributary of Kurram River, with a maximum height of 36.6 m or 120 feet and storage capacity of 12.10 million m^3 or 98,000 acre feet, feeds the new right bank canal through an intake channel whenever the supplies in the Kurram River through the weir are not sufficient. This commands 60,700 hectares or 150,000 acres. The Baran Dam and right bank Marwat Canal were completed in 1962.

Replacement Plan Works under the Indus Water Treaty

According to the Indus Waters Treaty concluded in 1960, India will be entitled to exclusive use of the waters of the eastern rivers--the Ravi, the Beas, and the Sutlej, while Pakistan will be entitled to the use of the waters of the western rivers--the Indus, the Jhelum and the Chenab, except for certain insignificant consumptive uses by India for areas specified in the Treaty.

This allocation of Indus river waters has necessitated the construction of a number of works called the Replacement Plan Works which comprise the following projects:

(1) Mangla Dam Project.
(2) Tarbela Dam Project.
(3) Link Canals Project comprising (i) the Trimmu-Sidhnai Link, (ii) the Sidhnai-Mailsi-Bahawal Link, (iii) the Rasul-Qadirabad Link, (iv) the Qadirabad-Balloki Link including the Lower Chenab Feeder, (v) the Balloki-Suleimanki Link II, (vi) the Pakpattan-Islam Link, (vii) the Chashma-Jhelum Link, and (viii) the Taunsa-Panjnad Link.
(4) Barrage Project comprising (i) the new Sidhnai Barrage on the Ravi, (ii) the Mailsi Gated-Syphon on the Sutlej, (iii) the Qadirabad Barrage on the Chenab, (iv) the New Marala Barrage on the Chenab, (v) the New Rasul Barrage on the Jhelum, (vi) the Chashma Barrage on the Indus.
(5) Remodeling of existing links, barrages and canal systems--(i) the Balloki-Suleimanki Link, (ii) the Marala-Ravi Link, (iii) the B. R. B. D. Link (Bambanwala-Ravi-Bedian-Dipalpur Link), (iv) the Balloki Headworks, (v) the Trimmu Headworks, (vi) the Upper Jhelum Canal, (vii) the Mailsi Canal system, (viii) the Bahawal Canal system and (ix) the Canals near Sidhnai.
(6) Tubewells and Drainage Schemes to offset the additional drainage problems created as the result of construction of the large system of link canals.

The Replacement Plan Works are scheduled to be implemented in two phases. Phase I includes the five projects, the Mangla Dam, the Trimmu-Sidhnai Link, the Sidhnai Barrage, the Sidhnai-Mailsi-Bahawal Link, and the Mailsi Syphon. Excluding the Mangla Dam which was completed in 1967, the other projects in this phase were largely completed in 1965. The remaining projects of phase II were initiated in 1962-63 and scheduled for completion in the early 1970's.

In addition, steps have been taken to set up a flood warning system in the catchment areas of the rivers in which major projects of the Indus Basin Settlement Plan are located.

The Mangla Dam Project, which was essentially completed in November 1967, is multipurpose in design to conserve and control the flood waters of the Jhelum River. It envisages the construction of three dams to contain the reservoir, the Mangla in the Jhelum main, the Sukian dyke on the southeast periphery of the reservoir and the Jarikas Dam across the Jari Nallah. The total length of the three dams is nearly 11 km or seven miles.

They are all of the rolled earth-fill type and require a total fill of over 82.57 million m^3 or 108 million cubic yards which makes the Mangla one of the largest earthfill dams in the world.

Mangla Dam has a sloping impervious core of rolled clay founded on bed rock. The main dam is 3.353 m or 11,000 feet long and 115.8 m or 380 feet high above the river bed and forms a reservoir of gross capacity of 7,154 million m^3 or 5.80 million acre feet and live storage of 6,414 million m^3 or 5.20 million acre feet in the first stage involving 60 million m^3 or 78 million cubic yards of earthfill. It has, however, design provision for increasing its elevation by another 15 m or 50 feet at a later date. The reservoir extends about 64 km or 40 miles upstream of the dam, causing the submergence of 26,345 hectares or 65,100 acres of land.

The 15 m or 50 feet higher elevation of the dam would increase the gross storage capacity of the Mangla Reservoir by from 4,440 million m^3 or 3.6 million acre feet to 11,040 million m^3 or 8.95 million acre feet.

The dam is located upstream of the present regulator of the Upper Jhelum Canal. The main spillway of the dam, which is on the right bank, has nine Tainter gates, each 11 m (36 feet) wide and 12.2 m (40 feet) high. There are five diversion tunnels on the left bank, each of diameter of 9 m or 30 feet and 610 m or 2,000 feet in length.

The subsidiary embankment at Sukian is 5,180 m (17,000 feet) long with a maximum height of 24.4 m (80 feet); the Jari Dam across the Jari Nallah is 1,737 m (5,700 feet) long and 71.3 m (234 feet) high. The two together constitute 23 million m^3 (30.27 million cubic yards) of earthfill.

At the stimated rate of silting of 49.34 million m^3 (40,000 acre-feet) per year, the live storage capacity of 6.414 million m^3 (5.20 million acre-feet) will reduce to 1,233.5 million m^3 (1.0 million acre-feet) in 94 years. The total life of the reservoir, after the dam is raised to its full height is estimated to be 200 years.

<u>The Tarbela Dam</u> is a multipurpose project. This will be a rockfill dam about 147.8 m (485 feet) high. Its length at the crest elevation of 477 m (1,565 feet) above mean sea level will be 2,743 m (9,000 feet). Its two Ogee-type spillways will have discharging capacities of 18,406 m^3/s (650,000 cusec) and 23,786 m^3/s (840,000 cusec). The spillway crest will be at an elevation of 454.76 m (1,492 feet) above mean sea level and it will have seven Tainter gates, each about 15.24 m by 17.68 m (50 feet by 58 feet) in size.

The reservoir will have a gross capacity of 13,692 million m^3 (11.1 million acre-feet) and a live storage of 11,471 million m^3 (9.3 million acre-feet). The principal purpose of the project is to create a reservoir with sufficient storage that it can be drawn upon to supplement the dry season run-of-river flows for downstream irrigation by the integration of surface and ground water.

The Inter-River Link Canal Project--The eight inter-river link canals, included under the Replacement Plan, take off from various rivers with the aid of four new barrages and one new syphon. The northern most Link, the Rasul-Qadirabad Link, will switch the Jhelum water (including releases from the Mangla Storage with the aid of a barrage just above Rasul) to the Chenab at Qadirabad where a new barrage has been built. From the Qadirabad, the next link, the Qadirabad-Balloki Link, takes the replacement supplies to the Ravi upstream of the Balloki headworks. From Balloki, the supplies received from the Qadirabad-Balloki Link, as well as those coming down the Ravi River through the existing Marala-Ravi Link, have to be conveyed to Suleimanki. The existing Balloki-Suleimanki Link could fulfill this purpose only partially, so in order to provide an adequate transfer capacity this link has been remodelled in the first 22.5 km (14 miles) and a new link of a capacity of 184 m^3/s (6,500 cusec) has been constructed from this point on the Suleimanki. This new link, the Balloki-Suleimanki Link II is the third of the series of the transfer works. The Pakpattan-Islam Link is the fourth link to transfer 34 m^3/s (1,200 cusec) from Pakpattan Canal to Islam headworks.

Two other link canals, the Trimmu-Sidhnai and the Sidhnai-Mailsi-Bahawal, carry surplus waters of the Jhelum and the Chenab from Trimmu to a new barrage near Sidhnai on the 'Ravi' and from thereon to the Sutlej River near Mailsi. This link crosses the Sutlej River through a syphon, instead of a barrage to link up with the Bahawal Canal system. There are two more link canals, the Chashma-Jhelum and the Taunsa-Panjnad taking off, respectively, from the Indus at Chashma where a new barrage is being built, and from the Indus at Taunsa where a barrage already exists. The Chashma-Jhelum Link carries the surplus water of the Indus including the releases from the Tarbela Dam, to the Jhelum River and this water would supplement the existing canals taking off from the Trimmu Barrage and also supply the new Trimmu-Sidhnai-Mailsi-Bahawal Link Canals system. The Taunsa Panjnad Link would transfer 34 m^3/s (1,200 cusec) of the Indus waters to the Chenab for use of the existing Punjnad canals.

The overall length of the new link canals is about 663 km (412 miles), involving earthwork of about 263 million m^3 (344 million cubic yards). These link canals individually carry discharge varying from a minimum of 34 m^3/s (1,200 cusec) to a maximum of 614 m^3/s (21,700 cusec). Their aggregate discharge is nearly 2,832 m^3/s (100,000 cusec).

The Barrage Projects--The Replacement Plan also stipulates the construction of five barrages, namely, the Chashma on the Indus, the new Rasul on the Jhelum, the new Marala on the Chenab, the Qadirabad on the Chenab, the New Sidhnai on the Ravi and one syphon under the Sutlej at Mailsi for carrying water from the western rivers to the areas in Pakistan now being irrigated by the Ravi and Sutlej Rivers.

The Chashma Barrage is being constructed on the Indus near the village of Chashma, about 48 km (30 miles) downstream of the existing Kalabagh Headworks. The Chashma-Jhelum Link, one of the largest canals in Pakistan, has a capacity of 614 m^3/s (21,700 cusec) and takes off at this barrage and falls into the Jhelum. The barrage is 1,280 m (4,200 feet) long and is designed for a maximum flood of 28,320 m^3/s (1 million cusec).

The Rasul Barrage on the Jhelum River is located about 4.8 km (3 miles) downstream of the existing Rasul weir to feed the Rasul-Qadirabad Link having a capacity of 538 m^3/s (19,000 cusec). The barrage is 978 m (3,209 feet) long and is designed to pass a flood of approximately 24,069 m^3/s (850,000 cusec).

The New Marala Barrage across the Chenab River is located just downstream of the old barrage. The barrage is 1,363 m (4,472 feet) long and is designed to pass a flood of approximately 31,149 m^3/s (1.1 million cusec).

The Qadirabad Barrage on the Chenab River is located about 29 km (18 miles) downstream of existing Khanki Weir. The Qadirabad-Balloki Link, having a capacity of 527 m^3/s (18,600 cusec) is fed at this barrage. Another link canal called the Lower Chenab Canal (LCC) feeder, 32 km (20 miles) long of a capacity of 116 m^3/s (4,100 cusec), takes off from the barrage to connect Lower Chenab Canal. The barrage is 1,028 m (3,373 feet) long and is designed for a flood discharging capacity of 25,485 m^3/s (900,000 cusec).

The Sidhnai Barrage is the fifth barrage which is located on the Ravi, about 10 km (6 miles) upstream of the existing Sidhnai barrage. The Sidhnai-Mailsi-Bahawal Link, having a capacity of 286 m^3/s (10,000 cusec), takes off at this barrage. The new Sidhnai Barrage is about 213 m (700 feet) long and together with the Sidhani spill channel of 1,274 m^3/s (45,000 cusec) discharge, it has a flood discharging capacity of 5,522 m^3/s (195,000 cusec).

The Mailsi Syphon is a reinforced concrete structure about 488 m (1,600 feet) long, consisting of 5 square barrels, each 4m x 4m (13.5 feet x 13.5 feet) in size and having a total capacity of about 142 m^3/s (5,000 cusec). It is a longer syphon than that constructed in 1951 to cross the Bamganwala Ravi-Dipalpur Link across the Ravi River. The designed waterway is for a maximum flood of 12,148 m^3/s (429,000 cusec).

The five barrages and the Mailsi Syphon have a total length of nearly 5.63 km (3.5 miles), having an aggregate flood discharging capacity of 127,426 m^3/s (4.5 million cusec) and can divert into the canals supplies totalling nearly 3,058 m^3/s (108,000 cusec).

Small Irrigation Scheme Development

Before independence, only a small number of small scheme irrigation development projects were undertaken, and most of these were located in the state of Baluchistan. The Small Dams Organisation in the Agriculture Development Corporation (this organization was abolished in early 1972) initiated the construction of a number of small dams in the dry and hilly tracts of West Pakistan. Over 500 such dams are planned which could provide water for nearly one million acres.

Groundwater Development Program

Under the program for the control of waterlogging and salinity, the first large-scale project was launched in Central Rechna Doab in 1959 under the designation Salinity Control and Reclamation Project (SCARP) I. The construction of 2,034 tubewells in this project was completed in 1962. As a result of the operation of these tubewells, the waterlogging in the project area has been minimized and a major part of the salinity damaged land reclaimed. As the result of the additional irrigation supplies available from pumping of tubewells, the cropping intensity in the area has increased to over 100 percent as compared to the pre-project intensity of 78 percent.

In addition to SCARP I, work has been started on three more SCARPs in the Upper Indus Plain and about 3,398 additional tubewells have already been installed as a part of these three projects, thus making a total of 5,441 tubewells completed by 1969 in the Upper Indus Plain. It is estimated that a further 1,069 tubewells will be installed by the end of the Third Five-Year Plan ending in 1970 in the Upper Indus Plains. Works are also in hand on the planning of subsequent SCARPs both in the Upper and Lower Indus Plains. Summary of the SCARPs initiated as of 1970 follows:

Sr. No.	Project	Culturable area million hectares	Culturable area million acres	No. of Tube-wells	Status
1	2	3	4	5	6
UPPER INDUS PLAINS					
1.	SCARP I	0.445	1.1	1,796	In operation since 1962.
2.	SCARP II	0.769	1.9	2,500	1,398 wells already completed.
3.	SCARP III	0.405	1.0	1,637	1,065 wells completed.
4.	SCARP IV	0.486	1.2	2,034	935 wells completed.
5.	SCARP V	0.348	0.86	1,155	---
6.	SCARP VI	0.676	1.67	2,060	---
LOWER INDUS PLAINS					
1.	Khairpur Tubewell Drainage Project	0.129	0.318	540	Project virtually completed.
2.	Larkana Shikarpur Drainage Scheme	0.234	0.578	---	Surface drainage project completed.
3.	Rohri North	0.283	0.70	1,269	---

Regions under Irrigation

As a consequence of a century of planning and development, West Pakistan has the largest integrated irrigation system in the world. The nature and scope of this system is depicted in Figure 1.6.

Problems of Irrigated Agriculture

Over the last 100 years of irrigated agriculture in the Indus Basin a number of problems have arisen and many of them resolved. Below are some of the pressing problems confronting irrigated agriculture development in West Pakistan.

1. Inspite of a sizeable water reserve, water shortage constitutes the major limiting factor for full utilization of agricultural land in West Pakistan. The ratio of water potential to land potential is 189 million acre feet to 199 million acres of land which is less than one acre foot of water per acre of land.

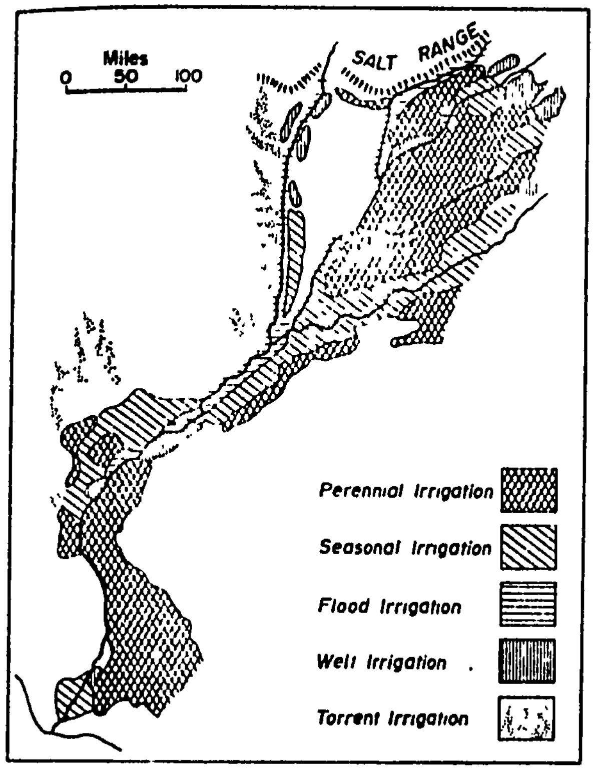
2. With the introduction of larger-scale irrigation in the Indus basin, the groundwater table has rapidly risen. As natural drainage is inadequate and artificial drainage not provided, extensive irrigation has led to waterlogging in the low-lying areas and the groundwater table has risen in large areas to within 1.5 m to 3 m or 5 to 10 feet of the surface. The canal systems were generally designed to command as much land as possible in that maximum returns would be obtained from the sale of project lands and subsequent taxation. For this reason, the cropping intensities adopted for the design were low, ranging from 60 percent to 80 percent and were often half the intensities which the land would be capable of supporting. The supplies designed to serve the largest number of people caused the water to be spread over the land somewhat thinly. This resulted in bringing the harmful salts already present in the soil profile to the surface. In the high water-table areas this upward movement of the salts was further accelerated by capillary action.

   Waterlogging and salinity have destroyed extensive areas of once productive land. The effect of salinity on agricultural production in West Pakistan shows that the annual value of all agricultural products grown in West Pakistan in 1960 was about Rs. 4,850 million, and that if there had been no decrease caused by salinity the annual value would have been greater by Rs. 1,230 million, i.e., 25 percent more. Furthermore, the deterioration is developing at the rate of Rs. 32.1 million a year or slightly less than one percent of present annual value of agricultural products.

   The area of productive land annually damaged by salinity was estimated in 1945-1946 to be about 16,200 to 20,200 hectares or 40,000 to 50,000 acres. In recent years this has more than doubled and is now approximately 40,500 hectares or 100,000 acres per year.

Figure 1.6

West Pakistan: types of irrigation*



*Taken from B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan and Ceylon, (London: Heinemann Educational Books, Ltd., 1969), 99.

3. There is considerable variation in the amount of water diverted during the flood season and the winter season, depending on the availability of waters in the rivers. The canal system in the absence of intermediate regulators along the distributaries and minors can only be run at two-thirds to three-quarters of the capacity. This necessitates a system of rotated closures of the distributaries during periods when less than two-thirds full supply conditions are in operation. Another important problem of the distribution system is the necessiry of keeping channels in regime by excluding silts from the canals.

4. In some of the project areas like the Thal and the Taunsa, the soil is highly sandy with a low moisture holding capacity and a high rate of infiltration. These areas lie in tracts having negligible rainfall, high temperature, and frequent wind and sand storms. Crops growing in these areas experience problems of soil stabilization, crop protection from sand storms, conveyance losses of water, and frequency and depth of irrigation.

5. Although the topography of the Indus Plains is generally flat but micro-topography creates problems for irrigation. All the areas irrigated from a channel are not irrigated with equal ease. Conveyance losses increase in irrigation of fields of high contour levels. In serious cases of this kind, an additional allowance of water is made. Generally, the crop yields in the higher contour areas are lower than in the other areas. Efficiency of irrigation in many cases has been increased by land grading, levelling and terracing.

Research Note on Water Logging and Salinity. The design of the early irrigation schemes in the Indus basin did not usually provide for long term changes in the hydrology that result as a consequence of massive irrigation. Many acres of once productive land are being lost to cultivation. It is estimated that 100,000 acres each year and going out of production along with vast acreages becoming less productive through progressive salinification and water logging.

The basic problem is the rise of the saline groundwater within the reach of plant roots which is a consequence of the massive application of irrigation river water. The irrigation water which percolates into the ground becomes more saline than the river irrigation water that was first applied. This problem is well illustrated in the experience of the Khairpur District which is located close to Sukkur and which has been a subject of recent investigations with the view of finding an economic solution to the Indus basin water logging and salinity problem.[12]

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[12]More complete details of this investigation is found in Sir Alexander Gibb and Partners, International Land Development Consultants and Hunting Technical Services, Programme for the Development of Irrigation and Agriculture in West Pakistan (London: Metcalf and Cooper, Ltd., 1966), volume 20, Annexure 15J - Lower Indus Project Reports.

In brief, from the Sukkur Barrage the large Rohri canal passes through Khaipur to the south. No feeder canals branch off it, but the Rohri canal does have a slight effect on the underground hydrology of the district because of seepage from its unlined channel. Small canals deliver water to the irrigation fields.

From the start of perennial irrigation in 1933 it was realized that the underground water movements must be monitored and that preventative measures be taken to arrest the eventual water logging and salinity problem. The "water balance" sheet developed by the Hunting Technical Services, a British based engineering firm, illustrates the process of water logging and salinity.

> Income of water into the Khairpur Command (the area supplied by the two Khairpur canal feeders) is made up of:
>
> 2,000,000 acre-feet from the canal feeders;
> 310,000 acre-feet from rainfall;
> 90,000 acre-feet by seepage from the Rohri Canal;
>
> 2,400,000 acre-feet
>
> The debit side of the account is less certainly known but is estimated thus:
>
> 1,000,000 acre-feet transpired by 520,000 acres of crops and cultivated soil;
> 22,000 acre-feet evaporated from water surfaces;
> 20,000 acre-feet draining away from the region below the surface;
> 30,000 acre-feet being added each year to the groundwater held in the area;
> 1,328,000 acre-feet presumed transpired and evaporated from wild vegetation and uncropped land.
>
> 2,400,000 acre-feet.

Of the 2.4 million acre feet coming into the area, most of it Indus river-water, only 20,000 acre feet drains away and 30,000 acre feet remains in the subsurface. Since the water evaporated and transpired by the plants contains no salts, it follows that most of the salt content of the incoming water is held in the soil and groundwater and that the increasing of salinity is inevitable. The level of the water table is steadily rising through the annual addition of 30,000 acre feet and the salinity is the highest in the subsurface water.

Between 1933 to 1959 the mean depth of the groundwater table has risen from 4.8 fbet insome areas to 16.4 feet in others. The groundwater table had risen to almost six feet of the surface in a 339,000 acre area and for almost a quarter of this area the water table was less than three feet. About 170,000 acres of the Khairpur canal command was considered sufficiently saline to affect all field crops.

If, in the long run, the productivity of the lands now being irrigated, is to be maintained, careful controls of salinity levels of water for the entire Indus basin will have to be worked out.

Future Plans[13]

The irrigation system of the Indus plains commands an area of about 15 million hectares or 38 million acres and comprises some 61,155 km or 38,000 miles of canals. By 1971, after completion of works under construction under the terms of the Indus Waters Treaty, the main and link canal headworks would be served partly from a major storage dam at Mangla, 15 barrages, three weirs and a hydro-electric power-cum-irrigation dam at Warsak.

The total irrigated area is covered essentially by 42 principal canals; of which four are being partitioned by the link canals now under construction. The total CCA is 13.56 million hectares or 33.5 million acres, although in practice not more than about 10.12 million hectares or 25 million acres receive surface water supplies, the rest is classified as culturable waste and a large proportion of it is in the Lower Indus region. About 8.22 million hectares or 20.3 million acres are designed for non-perennial supplies usually from mid-April to mid-October. Non-perennial areas do, however, receive occasional rabi water and in some years fairly consistent deliveries reach the farmers, but not as a right and only when river flows are surplus to the requirements of the perennial areas. With these irregular rabi supplies, supplemented by Persian wheel and tubewell water, rabi intensities often reach levels comparable with those in perennial areas.

Persian wheels, normally powered by animals, have always made an important contribution to irrigation in rabi, in perennial, non-perennial and uncommanded areas. It is estimated that there are about 200,000 Persian wheels in the Basin, but the discharge of even an efficient one is only about one-tenth of a cusec and on an average they are operated for only about 1,000 hours a year. Recently, there has also been considerable activity by enterprising farmers in the installation of tubewells. It is estimated that about 100,000 private tubewells with an average capacity of about one cusec each have been installed in the Indus basin.

Besides the private tubewells, the public tubewells under the SCARP have greatly improved the drainage and irrigation facilities in project areas. By mid-1968, 5,000 tubewells had been completed in the five SCARPs.

Until recently there has been virtually no development or surface storage to regulate the riverflows. The dam at Warsak on the Kabul River,

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[13]For more details see Lieftinck, Sadove, and Creyke, Water and Power Resources of West Pakistan, Baltimore, 1969, volume 11, 63.

a tributary of the Indus River, is used primarily as a regulator for hydro-electric generation. The commissioning of Mangla Dam on the Jhelum River in 1967 with an initial live capacity of 6,414 million m^3 or 5.2 million acre-feet was the first major storage on the system. The Mangla storage will, however, serve essentially as a replacement for the loss of flows from the Ravi and Sutlej Rivers. The raising of Chashma Barrage will provide additional storage of 616.7 million m^3 or 0.5 million acre-feet.

The estimated irrigation deliveries to the watercourse from all sources under present conditions are shown below:

Summary of watercourses deliveries—1965

Sources	Amount of delivery	
	million m^3 per year	million acre-feet per year
Surface Water Canals	71,542	58.0
Ground Water		
Public Tubewells	3,330	2.7
Private Tubewells	6,537	5.3
Persian Wheels	2,097	1.7
Total	83,506	67.7

The plans for future development, apart from the completion of the Indus Basin Replacement Works including the Tarbela Dam, call for a large-scale program of public tubewell development supplemented with private tubewell installations. By 1975 the rate of annual groundwater withdrawal is projected at 37,004 million m^3 or 30 million acre-feet against 11,965 million m^3 or 9.7 million acre-feet in 1965. The withdrawal of 37,004 million m^3 or 30 million acre-feet would require about 20,000 public tubewells of 85 to 113 m^3 l/s (3 to 4 cusec) capacity and about 50,000 private tubewells of 28 l/s (1 cusec) capacity or less. By 1985, this figure is expected to reach 49,339 million m^3 or 40 million acre-feet. Most of this development is proposed in the public sector.

Along with the groundwater development, a program of canal enlargement is also proposed; i.e., 0.405 million hectares or 1 million acres being provided by enlarged channels by 1975 and another 2.023 million hectares or 5 million acres by 1985.

While sub-surface drainage would be achieved side by side with groundwater development in the fresh groundwater areas, in the areas underlain by saline groundwater and these subject to frequent storm water damages, sub-surface and surface drainage would have to be provided and the future development plans provide for them.

After the full groundwater development, additional development would depend upon additional surface storage and would require enhanced and larger water transfer facilities.

C. The Irrigation System: Its Water Laws and Operations

Water Laws

This section includes both the domestic as well as international treaties and agreements.

Domestic Water Laws.[14] Pakistan became a sovereign country on August 14, 1947. The provinces of Pakistan retained the water laws which were in force in those territories before independence. The Northern India Canal and Drainage Act of 1873 continues to apply generally in the provinces of the Punjab, the former Bahawalpur States, and the North West Frontier; and the Bombay Irrigation Act of 1879 in the Sind Province. Parts of Baluchistan and the States, excluding Bahawalpur and Khairpur, however, do not appear to have any written legislation concerning water. Recently, Canal and Drainage Act of 1873 has been enforced in the area formerly known as Baluchistan.

Canal and Drainage Act of 1873--This act together with its succeeding amendments and modifications is the basic law concerning water in the Punjab and North West Frontier Provinces. According to the general principles of this law, ownership control and administration of natural and public water resources are vested in the Government, provided that the water of any river, stream, natural canal, lake or any other natural collection of still water is recognized by notification in the official gazette.

At any time after the above mentioned recognition, any canal officers, duly empowered, may enter upon lands for the purpose of checking the water supply and making inquiries and inspections to regulate water supply for repairs and to prevent accidents (Section 6). Sections 7 to 13 deal with compensations which might be awarded in case of any damage caused by the exercise of the above mentioned rights. They specify the damages for which compensation shall be granted, limit the time during which claims must be presented, and regulate the procedure to be followed for inquiry into claims.

The Government exercises full rights in the matter of diversion of water from the natural sources, the use of such waters and protecting any prior rights to them. The Government may also order the persons using any watercourse to construct works for passing water across roads, etc. If the order is not executed, the Government may construct with work and recover the cost as if it were an arrear of land revenue.

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[14]For further information beyond this section, see Dante A. Caponera (ed.), Water Laws in Moslem Countries, FAO Development Paper No. 43 (Rome, Italy: Food and Agriculture Organisation, United Nations, 1954), 160-66, and Ch. Mohammad Hussain Jahania, The Canal and Drainage Act (Lahore: The Mansoor Book House, 1968).

Any person, desiring to use water or constructing a new watercourse or transferring an existing watercourse from another person, must apply to the divisional or subdivisional canal officer. Sections 16, 19, 20, 22, 23 and 24 deal with the procedure to be followed in filling the application, the decisions to be taken by the Government, and the recovery of the amounts of water charges due.

Sections 31 and 32 deal with the rules to be followed in the absence of written contracts for the supply of water. These sections deny users any rights to sell or sublet the right to use canal water to other persons.

Any person making unauthorized uses of water shall be liable to payment of charges for such use which, in addition to penalties, shall be made recoverable. Sections 36 to 44 deal with water rates, and sections 45 to 47 with the procedure to be followed for the recovery of such charges.

Sections 49 to 54 deal with canal navigation. Drainage is dealt with in Sections 55 to 63. These Sections empower the Government to prohibit obstructions or to order their removal. The Government may also prepare schemes for the construction and improvements of drainage works and make decisions on compensation claims and their limitation.

The procedure for obtaining compulsory labor for urgently required irrigation or drainage work is governed by Sections 60 to 64. A list of the persons subject to this compulsory labor shall be prepared by the collector (head revenue officer of a district). All persons engaged on such works shall be entitled to a payment of rates which shall not be less than the highest prevailing local rates in the area for similar work. A new law on public calamities was, however, enacted in January, 1952. It is called the Punjab National Calamities Prevention and Relief Act of 1951 in which flood prevention, control and relief are considered.

Bombay Irrigation Act of 1879 (Applicable to the Sind Province). According to the general principles contained in this law, ownership, control and administration of natural and public water resources are vested in the Government for the water of any river or stream following a natural canal, any lake or any other natural collection of still water specified under Section 5 of the Act.

At any time after the said specification, any duly empowered officer may enter upon lands for the purpose of controlling the application of water supplies, for inquiry, for inspection and regulation of the water supplies, or for repairs and the prevention and regulation of the water supplies, or for repairs and the prevention of accidents, etc. (Sections I to II).

The Government may prohibit the formation of obstruction of rivers, etc., within certain limits defined in notices published in the official gazette (Sections 12 to 14), and it may also order the construction of drainage works (Section 15). The construction of new watercourses is subject to governmental permit (Section 16).

With respect to waters owned, controlled and administered by the Government, water rights are determined by agreements. No personal rights for water supplies are recognized except insofar as such rights were in existence prior to the notification under Section 5 of the Irrigation Act.

The Government exercises full rights to divert water from natural sources and to use such water except when this practice would infringe upon any prior rights to such waters. Compensations, which may be awarded in the case of damages caused by the exercising of the above mentioned rights, are governed by Sections 31 to 43 of the Act.

The procedure of obtaining compulsory labor for urgently required works or repairs is governed by Sections 58 to 60. A list of persons liable for such work shall be prepared by the collector. All persons so employed shall be entitled to payment at rates which shall not be less than the highest paid rates in the neighborhood for similar labor.

Penalties are dealt with in Sections 61 to 65. Offenses, according to the damage caused, shall be punishable if such acts do not amount to the offense of committing mischief within the meaning of the Penal Code. Maximum penalties imposed upon conviction before a magistrate, or a fine which may extend to 200 rupees, imprisonment for a term which may extend to six months, or both. Costs for the repair of obstructions, their removal and damages shall be collected from the person convicted of such offenses.

A few remarks are necessary concerning the laws connected with the development of groundwater, salinity control and reclamation. Groundwater is under the control of the Government in the Salinity Control and Reclamation Project area. No one party is permitted to draw water from a sub-soil-reservoir without securing a written permission or a license from the Government. Private tubewell operators are charged the rate of the ordinary canal water. Where the Government tubewells supply water to the cultivators for increase in irrigation from both the sources, i.e., canal water and irrigation water, the water rates charged for the zamindars are double the crop rates notified in that area. A new Act namely 'The Soil Reclamation Act, 1952 (Punjab Act XXI of 1952)' as amended by: (1) The Punjab Soil Reclamation (West Pakistan Amendment) Ordinance, 1964--West Pakistan Ordinance No. V of 1964 and (2) The West Pakistan Laws (Amendment) Ordinance 1965--West Pakistan Ordinance No. XXXIV of 1965 is applicable to all Salinity Control and Reclamation Projects in West Pakistan and it provides the necessary legal control for the preparation and implementation of these projects.

International Treaties and Agreements

A brief summary of the principal international treaties and agreements are noted below.

Treaty with Afghanistan, 1934. The British Indian and Afghanistan governments concluded on February 3, 1934 a Treaty concerning the Arnawai

Khwar river basin. This treaty is binding on the successor Government of Pakistan. The Treaty contained the following provisions:

> 2. (a) That the people of Dokalim shall be allowed to take water required for the irrigation of their lands in Dokalim from the Arnawai Khwar above the boundary fixed; and (b) that the people of Arnawai may be allowed to float wood required for local use down the portion of the Arnawai Khwar which forms the international boundary.
>
> 3. In regard, however, to the decision mentioned in paragraph 2(a) above, it will, of course, be understood that without the consent of the local British Authorities, no new water channel shall be constructed above the boundary fixed.

Indus Waters Treaty, 1960. This treaty makes available all the waters of the Eastern Indus Rivers (the Sutlej, the Beas, and the Ravi combined together) for the unrestricted use of India, except as otherwise expressly provided in Article II of the treaty. The treaty provides that Pakistan shall receive for unrestricted use all those waters of the Western Rivers (the Indus, the Jhelum and the Chenab combined together) which India is under obligation to allow to freely flow under the provisions of paragraph (2), Article III of the treaty.

The average annual flow of the Indus and its principal tributaries at their rim stations (i.e., the upper-most gauging station on each river, generally near the point where it debouches from the hills into the plain) is as follows:

Name of river	Mean volume of flow million m^3 (million acre-feet)		
	Rabi (October to March)	Kharif (April to September)	Annual
Indus (including Kabul)	16,029 (13.0)	94,325 (76.5)	110,354 (89.5)
Jhelum	5,549 (4.5)	22,317 (18.1)	27,866 (22.6)
Chenab	4,562 (3.7)	24,413 (19.8)	28,975 (23.5)
Ravi	1,480 (1.2)	6,412 (5.2)	7,892 (6.4)
Beas	2,960 (2.4)	12,947 (10.5)	15,907 (12.9)
Sutlej	2,466 (2.0)	14,180 (11.5)	16,646 (13.5)
	33,046 (26.8)	174,594 (141.6)	207,640 (168.4)

The contribution to river flow from the plains is only about 2,466 million m^3 or 2.0 million acre feet.

Irrigation, mainly by inundation, was being practiced along the Indus and its tributaries from time immemorial. From about the middle of the nineteenth century, however, a large number of highly developed canal systems were constructed in the Indus Basin, based entirely on the flow waters (as distinct from stored waters) of the rivers. By 1947, by the time of the birth of Pakistan, almost the entire rabi season flow of all the rivers, except for a small quantity on the Indus, was appropriated for irrigation. During the kharif season, while some surplus flow was still available on the Indus, the Jhelum and the Chenab for use on new irrigation developments, on the other three rivers, namely the Ravi, the Beas and the Sutlej, it was only during 70-80 days between July and September that there was any surplus water left which had not been appropriated for irrigation. Large quantities were, however, available on almost all the rivers for storage and further development.

After the political boundaries between India and Pakistan were drawn in 1947, it was found that of the 10.5 million hectares or 26 million acres of land annually irrigated in the Indus Basin, about 8.5 million hectares or 21 million acres lie in Pakistan and only 2 million hectares or 5 million acres in India. The population dependent on the Indus system in Pakistan was about 25 million. Most of the existing irrigation canals were also in Pakistan.

Of the total volume of flow in the Indus rivers, about 81,411 million m^3 or 66 million acre feet was being used by canals in Pakistan and about 11,102 million m^3 or 9 million acre feet by canals in India. About 22,202 million m^3 or 18 million acre feet was lost because of seepage in the rivers and 92,513 million m^3 or 75 million acre feet flowed into the Arabian Sea.

After partition India wanted more irrigation water for the development of its extensive culturable but arid lands. Any such development in India had severe repercussions on Pakistan's established historic uses. Pakistan not only wanted to safeguard these uses but also to increase its irrigated area to meet the need of its growing population. The boundary had cut across two canals putting their headworks and upper reaches in India and the lower reaches in Pakistan. The sources of the rivers were also mainly in India.

After 12 years of negotiations, the last eight under the good offices of the International Bank for Reconstruction and Development, an acceptable settlement was concluded in the Indus Waters Treaty of 1960.

The Treaty comprises a Preamble, 12 Articles and eight Annexures A to H.

The Preamble sets out the objectives of the Treaty:

> the two Governments 'being equally desirous of attaining the most complete and satisfactory utilization of the waters of the Indus system of rivers and recognizing the need, therefore of fixing and delimiting, in a spirit of goodwill and friendship, the rights and obligations of each in relation to the other concerning the use of these waters and of making provision for the settlement in a co-operative spirit, of all such questions as may hereafter arise in regard to the interpretation or application of the provisions agreed upon.'

Article I lists the various terms used in the Treaty and the meaning assigned to them.

Under Article II all the waters of the Eastern rivers, the Ravi, the Beas, and the Sutlej, are allocated to India for its unrestricted use after the end of a Transition Period of 10 years. This means that about 14,800 million m^3 or 12 million acre feet of the waters of these rivers which were being allowed in 1947 for the Pakistan canals then dependent on these rivers would become available for exclusive use of new developments by India. In addition, India could utilize by storage works all the unused flood waters of these rivers for development of its irrigation. Annexure B allows some agriculture use to Pakistan on the tributaries of the Ravi from the available supplies in them, but Pakistan cannot have these supplies as a matter of right.

On the other hand, in Article III India has accepted the obligation to let flow all the waters of the Western rivers, the Indus, the Jhelum and the Chenab, for unrestricted use by Pakistan, after making certain withdrawals for specified uses there from in their drainage basin in India. These uses include domestic use, municipal use, industrial use and non-consumptive use (under Article I (ii) the term non-consumptive use does not include generation of hydro-electric power). Under the provision of Annexure G, India is entitled to irrigate, over and above the cropped area as on the Effective date (1st April, 1960) and the area irrigated by Ranbir and Pratap Canals for which the withdrawals have been fixed, an area of (a) 28,328 hectares or 70,000 acres from the Indus, in its drainage basin, (b) an area of 161,872 hectares or 400,000 acres from the Jhelum in its drainage basin and (c) an area of 91,053 hectares or 225,000 acres from the Chenab in its drainage basin of which not more than 40,468 hectares or 100,000 acres will be in the Jammu district. Besides, India can also irrigate an area of 2,428 hectares or 6,000 acres from the Chenab waters outside its drainage basin in the area west of Deg Nadi (Devak River) but the withdrawals are limited to a maximum of 3.4 m^3/s or 120 cusec.

Annexure D deals with India's entitlement for the development of hydro-electric power on the Indus, the Jhelum and the Chenab. These works have to conform to certain design criteria and are to be operated as specified in that Annexure.

India may also store on these rivers 4,440 million m^3 or 3.6 million acre feet for various uses. These storage works have to conform to a certain design criteria and are to be operated as laid down in Annexure E.

In other words, the uses by India on the Indus, the Jhelum and the Chenab are limited to those specified in the Treaty and the remaining waters of these rivers are to be let down for use by Pakistan. The supplies available under the Treaty to Pakistan will ensure continued irrigation supplies for all areas so far developed in Pakistan, whether from these rivers or from the rivers allocated under the Treaty to India and furthermore, for additional supplies for new development by Pakistan.

In Article IV Pakistan has agreed to use its best endeavors to construct and bring into operation, as early as possible, that part of a system of works which will accomplish the replacement from the water allocated by the Treaty to Pakistan of water supplies for irrigation canals in Pakistan which were dependent in 1947 on the rivers allocated under the Treaty to India. This Article also sets out the mutual obligations which India and Pakistan have accepted with regard to the operation of river works, maintenance of river channels including natural drainages, construction and maintenance of artificial drainage flowing from one country into the other, pollution of river waters and recovery and restoration to owners of timber and other property floated or floating down the rivers.

It has also been agreed that, except as expressly provided in the Treaty, nothing contained therein "shall be construed as affecting the territorial rights over the waters of any of the rivers or the beds or banks thereof, or as affecting existing property rights under municipal law over such waters or beds or banks."

Article V provides for the payment by India, in ten equal installments of a sum of pounds sterling 62 million towards the costs of the replacement element of the system of works to be undertaken by Pakistan on the rivers Indus, Jhelum and Chenab. This payment by India "shall not be construed as conferring upon India any right to participate in the decisions as to the system of works which Pakistan would construct or as constituting an assumption of any responsibility by India or as an agreement by India in regard to such works."

Article VI provides for an exchange between the two countries of the entire data of river flow and canal withdrawals, etc., for all the rivers and canals in the Indus basin.

Article VII provides for future co-operation between the two countries in regard to the setting up of hydrological and meteorological stations, to the undertaking of engineering works by mutual agreement and to the supply of information in regard to such works which cause interference with the waters of the rivers as may be undertaken by either side.

In Article VIII the Parties have agreed to set up a Permanent Indus Commission composed of an Indian Commissioner and a Pakistan Commissioner. The Commission will establish and maintain co-operation between the two countries in the development of the waters of the Indus system of rivers. The Commission will make an endeavor to resolve by agreement all questions that may arise regarding the implementation of the Treaty. The Commission is also requested to undertake a tour of inspection of the rivers, once in five years for ascertaining the facts connected with various developments and works on the rivers and also when requested by either Commissioner.

Article IX and Annexures F and G provide for the settlement of such differences and disputes as may not be resolved by the Permanent Indus Commission. A two-tier arrangement has been provided as follows:

(1) Relatively simple differences on questions involving difference of opinion on technical matters shall be settled by the decision of a neutral expert to be specifically appointed in each individual case.

(2) As regards a dispute involving interpretation of the Treaty or alleged violation of any provision of the Treaty, an attempt will first be made to resolve the dispute by discussions between the two Governments with or without mediation, failing that the dispute will be referred for decision to a Court of Arbitration to be set up in each case.

In other Articles, it has been agreed that the Treaty governs the rights and obligations of each Party in relation to the other with respect only to the use of the waters of the rivers and matters incidental thereto and that the provisions contained in the Treaty shall not be construed by the Parties as in no way establishing any general principle of law or precedent. It has also been agreed that neither Party will invoke this Treaty in support of any of its own rights or claims whatsoever or in disputing any of the rights or claims whatsoever of the other Party, other than those rights or claims which are expressly recognized or waived in the Treaty.

Provision has been made for ratification of the Treaty and it has been agreed that the Treaty can be amended or terminated only by another Treaty concluded for that purpose between the two Governments. The Treaty came into effect from 1st April, 1960.

Annexure H sets out in great detail the regulations for the distribution of the waters of the Ravi, the Beas and the Sutlej during the Transition Period. The principle underlying these regulations is that the withdrawals to be made by India for new developments, in so far as these withdrawals would reduce supplies to Pakistan canals, shall be related to Pakistan's ability to replace these withdrawals from the waters allocated to it under the Treaty.

Irrigation System Operations

Irrigation Department. The existing system of administration for the control of execution, maintenance and operation of irrigation works and assessment of water charges has been developed through long history. Before 1955, the Irrigation Department of each province or State was headed by one or more Chief Engineers and Secretaries to Government, who had a number of Superintending and Executive Engineers (Divisional Officers) under them, who in turn had Sub-Divisional Officers and Overseers (Section Officers) in charge of portions of canals and connected works.

In October, 1955, significant administrative integration took place. The century-old system with Secretaries-cum-Chief Engineers in the Engineering Departments was changed and the status of the Chief Engineers office was reduced to an Attached Department.

In 1962, the century-old system of Technical Secretary, changed in 1955, was again reinstated and one Technical Secretary was appointed for the whole of the province assisted by six regional Chief Engineers. In the former province of Punjab, the assessment of water charges and water advantage rates is made by the revenue staff of the Irrigation Department working under the Executive Engineer, but in the former province of Sind by the Revenue Department. With the breakup of the one unit in 1970, the system was again changed, returning to many of the organizational patterns prior to the Ayub regime.

West Pakistan Water and Power Development Authority

The West Pakistan Water and Power Development Authority (WP-WAPDA) was established through the Provincial legislature in 1958.

The West Pakistan WAPDA, headed by a Chairman, is a wholly Government owned organization with a measure of autonomy and is charged with the responsibility of preparing an integrated plan for the development of water and power resources of West Pakistan. The authority is also responsible for construction of the major water and power projects. As agent of the Central Government, the Authority carries out all replacement plan works.

The WAPDA Board consists of a Chairman and three members. Work within the Authority is distributed on the basis of the Chairman being in charge of policies and the overall development, one member dealing exclusively with engineering, another with administration and the third with finance.

The Authority's operations are conducted through two main branches, the Water Wing and the Power Wing. The Water Wing's work has been distributed into several divisions. One is under Chief Engineer for development and co-ordination, who is concerned with general investigations and normal development work which is a part of the Five-Year Plans.

There is also a Chief Engineer for ground-water and reclamation, who does most of the construction work connected with the eradication of salinity and waterlogging. There is a third Chief Engineer in charge of the Water and Soil Investigation Division (WASID), which collects the basic data, does the field surveys and carries out the hydrological, geological and other types of investigations which are required before a proper scheme can be formulated. There is a fourth Chief Engineer who is in charge of the Indus Basin Project. This, in brief, is the organization at the headquarters on the water side, and it has its normal divisions and subdivisions further down the line.

Power Wing of WAPDA (West Pakistan) is administered on commercial lines. A General Manager heads the Power Wing and is assisted by the organizations of the operational Manager, Chief Engineer Construction, Chief Engineer, Planning, Development and Co-ordination and Chief Engineer Designs and Standards. The Operational Manager has under him four regional organizations each headed by a Regional Manager of the rank of Chief Engineer to look after the distribution of power. On the Generation and Transmission side, he is assisted by a Chief Engineer, Generation and Transmission. The General Manager (Power) is responsible to the Authority through one of its Members.

PART I: 2.

WATER MANAGEMENT IN PAKISTAN:
CASE HISTORY IN ORGANIZATIONAL CHANGE

by

Robert Schmidt

Part I

2.

WATER MANAGEMENT IN PAKISTAN:

CASE HISTORY IN ORGANIZATIONAL CHANGE

Among the many important factors in the continued development of new nations are their administrative organization and reorganization capacities. The question of how nations might alter and improve administrative structures so as to promote economic development and nation building is especially important for nations with a history of colonial rule, and is a question which has received considerable attention in comparative administration literature.[1]

The purpose of this paper is to examine the manner in which organizational change has taken place in Pakistan in the vital sector of water management. Similar to many other new nations, Pakistan has a rapidly growing population, relatively unmechanized agriculture, and a number of other problems common to the developing world. It also shares with a number of these nations remnants of a colonial administration which is not well suited to deal with these and related new and emerging problems. Thus, an important concern for Pakistan has been the modification of administrative structures.[2]

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[1]Edward W. Weidner, "Development Administration: A New Focus For Research," in Heady and Stokes (eds.), Papers in Comparative Public Administration, Ann Arbor: Institute of Public Administration, 1962, 97-114.

See also Irving Swerdlow, Development Administration (Syracuse: Syracuse University Press, 1963) and V. A. Pai Panandiker, "Development Administration: An Approach" in Nimrod Raphaeli (ed.), Readings in Comparative Public Administration, (Boston: Allyn and Bacon, Inc., 1967), 199-210.

[2]This task is reflected in Pakistan's administrative literature. See Albert Gorvine, "Administrative Reform: Function of Political and Economic Change" in G. Birkhead (ed.), Administrative Problems in Pakistan, (Syracuse: Syracuse University Press, 1966), 185-211. See also G. Ahmed, "Change in the Administrative Organization of the Government of Pakistan since 1953," Public Administration, 39(Spring, 1961), 355, 356.

Administrative structure and change are especially important in the water management system. Even though West Pakistan is predominantly dry land, her agricultural potential is high because extensive water resources are available for irrigation. The average flow of the Indus River and its tributaries is twice that of the Nile. Half of the water carried onto the Indus Plain is used to irrigate 23 million acres which makes it the largest single integrated system in the world. In addition to the rivers, there is an enormous underground lake of fresh water which, if properly exploited through the use of tube-wells and proper drainage, could serve as a valuable supplement to surface water.[3] The challenge to water management agencies has been to supply water in sufficient quantity to maximize agricultural production. This has led the government of Pakistan to undertake over the years an extensive reorganization of its water management system.

The history of Pakistan's water-related reorganization efforts will now be sketched out. The rate of change, the direction of change, and factors necessary to produce change in the administrative structures of the water management system of West Pakistan are discussed under three broad periods of time: First, the Independence Era from 1947-58; second, the Mobilization Era from 1958-1969; third, the Coordination Era, which is still in progress. Two hypotheses are tested: (1) reorganization tends to occur incrementally in a series of stages and (2) reorganization is successful only when there is a technical, administrative, and political impetus for it. The implication of these theses is, of course, that it is virtually impossible to simply "decree" reorganization. Successful reorganization is inextricably linked to a variety of environmental factors.

The Independence Era

Between 1947 and 1958 the Irrigation and Power Departments in the provinces and states of West Pakistan, inherited from the British-Indian Administration, were responsible for all water management in the Indus Basin. Apart from consolidation of these departments in 1955, technical and political problems retarded any organizational innovation. The chief technical problem had to do with maintaining and trying to increase the available supply of irrigation water. Given a scarcity of administrative personnel in the technical services, this was no easy task. To further complicate matters a water crisis with India erupted in April, 1948 in which India threatened to divert water from the three eastern tributaries

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[3] The White House, Report on Land and Water Development in the Indus Plain (Washington: U.S. Government Printing Office, 1964), 4. This report was compiled by a special presidential committee headed by Dr. Roger Revelle. The committee went to Pakistan, submitted an initial report and was asked to redo parts of it. The second report is the one cited above. We shall henceforth refer to it as Revelle II.

of the Indus and deprive Pakistan of water needed for 5.5 percent of the cropland.[4] The dispute was temporarily solved by the Inter-Dominion Agreement of May, 1948, but the question of future water resources remained critical and tended to discourage organizational innovation.

Attitudes which permeated both colonial and pre-colonial administration, and which grew out of the British and Moghul influences, also discouraged organizational change. Muneer points out that the bureaucracy occupied the paramount position in the government under the British.[5] The civil servant was not legally accountable to the public. In fact, top civil servants did not derive their positions from elected officials but were selected by certain service academies. These factors combined to give civil servants an overriding interest in maintaining the supremacy of the bureaucracy. G. Ahmed traces administrative attitudes in the post-colonial era to another source. He cites history to show that on the Indo-Pakistan subcontinent there had been a long tradition of administration going back to the thirteenth century. The Moghul kings of India developed a group of men called Mansabdars, from which came leaders in the army, peerage, and civil administration. Mansabdars were the first generalist administrators and had virtual jurisdiction over all executive, judicial, and military functions in their territories.[6]

Certain political realities also discouraged organizational innovation. Political dominance by the bureaucrat over the politician tended to reinforce the organization status quo. A second political reality was the felt need to consolidate the province and state Irrigation and Power Departments. Prior to 1955 Pakistan was composed of four provinces: East Bengal, West Punjab, Sind, and the Northwest Frontier Province. Additional jurisdictional subdivisions included the states of Behalwapur, Khairpur, Baluchistan, and the port city of Karachi. For the purpose of overall development of West Pakistan economically and politically, the subdivisions were merged into one unit. The "One Unit Scheme" created a sub-federation of West Pakistan. The existence of One Unit then created the rationale for a single government agency to handle the new province's water resources.

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[4] Aloys Michel, The Indus Rivers (New Haven: Yale University Press, 1967), 203.

[5] Muneer Ahmed, The Civil Servant in Pakistan (Karachi: Oxford University Press, 1964), 3-5.

[6] G. Ahmed, "Changes in the Administrative Organization of the Government of Pakistan since 1953," Public Administration, 39(London: Spring, 1961), 355-356.

The Mobilization Era

The era of mobilization for development began in 1958 when M. Ayub Khan assumed leadership and sought to mobilize the nation's resources toward a big development push. Earlier in the same year, the central government created two new agencies for water management; the Water and Power Development Authorities (WAPDA) of West and East Pakistan.

Three technical factors contributed to the creation of the West Pakistan WAPDA: (1) the need for integrated water storage and power production; (2) the need for a single agency to supervise and attract aid for the Indus Basin Project; and (3) the need to carry out groundwater and reclamation projects. The erection of the Warsak High Dam in 1948 suggested to government planners that West Pakistan was without an organization capable of directing planned and unified water and power development. In response to a Canadian offer to assist in the construction of a power and irrigation project at Warsak on the Kabul River above Peshawar, the Central Government established the Warsak Dam Corporation. However, as the corporation was involved with construction only, and since no provision had been made for power transmission, the task of building the transmission system was given, on an ad hoc basis, to the Pakistan Industrial Development Corporation (PIDC) which was to turn the lines over to the newly created West Pakistan Electricity Department as soon as the system was completed. This fragmentation of planning and execution pointed to the need for a single agency to carry out these functions in future projects.[7]

A second factor which led to the creation of WAPDA was the need for an effective agency to manage Pakistan's role in the newly conceived Indus Basin Project. At the time of partition nearly all of the irrigated land in northwest India went to Pakistan, even though the headwaters of the rivers remained in India. India, in the face of strong Pakistani objections, planned to divert irrigation waters from the rivers to her own lands. In 1951, David Lilienthal, long associated with the Tennessee Valley Authority in the United States, visisted India and Pakistan. Writing for Collier's magazine, he suggested that Indian and Pakistani differences over the control of the river waters could be solved by an engineering solution which would give the waters of the three eastern rivers to India and supply Pakistan's needs by constructing dams and reservoirs on the three western rivers and diverting stored water to the eastern river channels through link canals. This plan became the basis of the Indus Basin Treaty of 1960. To effectuate the construction of both dams and link canals, the Central government perceived the need for a new agency.[8]

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[7]Michel, The Indus Rivers, 348, 349.

[8]Guthrie Birkhead, "Government by Corporation: The Case of West Pakistan WAPDA," in Guthrie Birkhead (ed.), Administrative Problems of West Pakistan, (Syracuse: Syracuse University Press, 1966), 137.

A third factor which led to the creation of WAPDA was the increased realization of the magnitude of the waterlogging and salinity problem. This realization grew out of the Irrigation Department - United States Geological Survey investigations began in 1954. Planners in Lahore and Karachi were forced to think beyond the traditional methods of water management carried on by the Irrigation and Power Department.[9]

An additional factor provided impetus for alteration of the water-related bureaucracy. In 1953 the Ford Foundation engaged Professor Rowland Eggers of the University of Virginia to make a survey of administrative practices in Pakistan. Among other things Professor Eggers made proposals for the establishment of government corporations.[10]

In 1953 he stated:

> As a second principle of organization of the work of the executive branch, those activities of the government which are essentially commercial in nature should be organized as government-owned corporations, and should be permitted to operate with a maximum degree of independence of the controls necessary for the regular departments and ministries. As suggested at a later point, they should be put on business type budgets, and their accounts should conform to the best commercial accounting practices applicable to the type of business they transact. The government should deal with them financially on a net profit or loss basis. It should deal with them administratively as the sole shareholder, not as the board of directors.[11]

Professor Eggers' recommendations relative to public corporations were later seconded by Bernard Gladieux. Mr. Gladieux conducted a survey of the administrative aspects of planning for the Harvard advisory group, who at that time were consultants for the Natonnal Planning Board. While Eggers' recommendations were never printed, the Gladieux survey received official sanction and became part of the doctrine of the Five Year Plan.[12] Thus when WAPDA was created, its form was that of a public corporation.

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[9]Michel, The Indus Rivers, 350.

[10]Ralph Braibanti, "Transnational Inducement of Administrative Reform: A Survey of Scope and Critique of Issues," in John D. Montgomery and William J. Siffen, (eds.), Approaches to Development: Politics, Administration, and Change, (New York: McGraw Hill Book Co., 1966) 142-143.

[11]Rowland A. Eggers, "Ministerial and Departmental Organization and Management in the Government of Pakistan," Public Administration, 39 (London: 1961), 152.

[12]Braibanti, "Transnational Inducement," 144.

The political climate in late 1958 and the years following provided a favorable developmental climate for WAPDA. Not only did Ayub Khan's new regime make liberal use of corporations, it continued to view public corporations as viable structures for developing nations.[13]

With the creation of WAPDA, water management was in the hands of two agencies--the Department of Irrigation and Power, and WAPDA. The difference between them has been spelled out by Michel:

> Since its establishment in 1958, WAPDA has controlled both power and development and operations in West Pakistan, and with a few minor exceptions, all water development. (The Guda Project was transferred from the Irrigation Department to WAPDA, but the Irrigation Department retains a few small development schemes...) Surface water operations are still controlled by the Irrigation Department which still assesses and collects the water dues.[14]

The establishment of WAPDA signaled Pakistan's advance beyond a *status quo* orientation in water management. The nation had now organized itself for the coordination of water and power, the commencement of the Indus Basin Project, and the launching of the public groundwater program.

The Coordination Era

The third era in the history of water management in West Pakistan can aptly be termed the era of coordination. In 1960 the Central Government authorized a Food and Agriculture Commission (FAC) to make a study of Pakistan's agricultural needs and potential. The commission focused attention on maximizing agricultural production. It concluded that while water was but one of a number of agricultural inputs needed to raise production, crop output could be greatly increased if the application of water could be coordinated with the application of better seeds, fertilizers, insecticides, and credit and marketing facilities. Where the application of any one input might increase yields by twenty or thirty percent, coordinated application of all inputs could raise production by 200 and 300 percent. To effectuate this coordination, the FAC called for the concentration of efforts on a number of specified areas, with an eye toward eventual involvement of the whole nation in the coordinated approach.

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[13] Birkhead, "Government by Corporations," 121.

[14] Michel, *The Indus Rivers*, 352.

[15] *Ibid.*, 427.

To implement these recommendations the FAC suggested that the Central Government establish a public corporation in each wing to begin the coordinated approach. To this end, the Agricultural Development Corporations were established in 1961. The establishment of new project areas was a slow process. By 1958 only five project areas had been created, all of which were in "colonization" areas where new lands were brought under cultivation.[16]

Many aspects of the FAC report were incorporated into what has become known as the Revelle report. The Revelle report had its origin in 1961 when President Ayub visisted President Kennedy in America. At that time foundations were laid for an investigation of Pakistan water-logging and salinity problems which had been depriving West Pakistan of productive land. Following President Ayub's visit, a team of scientists was assembled under the direction of Jerome Wiesner and later Dr. Roger Revelle.[17]

Although the Wiesner-Revelle mission began as a study of water-logging and salinity, the recommendations in their final report dealt mainly with the integration of water and agricultural inputs. The primary recommendation of the Revelle report called for a reorientation of strategy for agricultural production in waterlogged and saline soil. Like the FAC Report, it called for coordination of water and agricultural inputs in project areas. This would shift the administration of agricultural production from structures based on function to those based on area.[18]

At the suggestion of the Pakistan government, the Revelle report also recommended a form of organization to manage the project areas. The recommendations were that the government of West Pakistan mobilize its efforts in the project areas around the legal powers of the Soil Reclamation Board. The Board would be renamed the Land and Water Development Board. Its members would include the Secretaries of the Departments of Irrigation and Power, Agriculture, Labor and Cooperatives, Local Government and Basic Democracies, Finance, and the Chairmen of WAPDA and the ADC.19

On the basis of the Revelle report, thus, the Land and Water Development Board was created in 1964. Although the model suggested was probably patterned after the Water Resources Council in the United States, the Revelle report inserted one new idea which changed the whole concept

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[16]West Pakistan Yearbook of 1960, (Lahore: Information Department, 1968), 46, 47.

[17]Michel, The Indus River, 475, 476.

[18]Revelle II, 4.

[19]Ibid., 16.

of the Board. Revelle Report II suggested that, "Project directors be given authority to supervise and direct project personnel...not merely to coordinate their activities.[20] This addition transformed the Land and Water Development Department into a regular line agency and made it a rival to other water management agencies for funding. Since the heads of these other line agencies are members of the Land and Water Development Board, conflicts of interest may explain why the LWDB has met only semi-monthly, and why the growth of new project areas has been slow.

The FAC and the Revelle Report had called for the coordination of water and other agricultural inputs. A different type of coordination was called for, however, by those specializing in water. With the growth of both public and private groundwater resources, the World Bank Study Group, on the basis of comprehensive survey conducted by the Irrigation and Agricultural Consultant's Association, recommended the coordination of surface and groundwater supplies for greater efficiency and flexibility.[21] Lieftinck and Associates, who were members of the Study Group remarked:

> Total water supplies under the present system might at certain times be more than adequate in tubewell areas while, elsewhere, crops are suffering shortages. Achievement of the full benefits of groundwater development would require changes in the present methods of allocating water. One of the most important changes required is that groundwater supplies from public tubewells should be treated jointly with surface water supplies in future allocations.[22]

To implement this the World Bank Study Group proposed an Irrigation Authority which would be responsible for the coordination of all water supplies. This body would make basic policy decisions on barrage allocations, dam release patterns and tubewell pumping policies with reference to both water and power considerations.[23]

The FAC, the Revelle Report, and the World Bank Study Group all began with a new technical assessment and concluded with suggestions for administrative innovations. The first two recommendations resulted in two additional water management agencies, but neither has been able to fully accomplish the objectives invisioned for them. The ADC in West Pakistan has been restricted to "colonization areas" and there has been

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[20] Ibid., 139.

[21] Lieftinck and Associates, Water and Power Resources, Vol. II, (Baltimore: Published for the World Bank by Johns Hopkins Press, 1969), 189.

[22] Ibid., 74.

[23] Ibid., 187.

little movement to begin more project areas. The LWDB has supervised a number of SCARP areas, but not on as many as envisioned by the Revelle panel. Further, little has been done to create the one Irrigation Authority called for by the World Bank Study Group. The failure of a new water management system designed for maximum coordination to develop reflects the lack of strong political impetus in this direction.

The political factors which will figure into any reorganization of water management agencies are complex. As there will be four separate provinces in the West Wing, these may well be four separate Departments of Irrigation and Agriculture.[24] An autonomous body such as WAPDA may remain intact and under direct control of the President.[25] In January of 1972 the ADC was dissolved and its field functions were relegated to the new provinces, while fertilizers were to be controlled by the Centre.[26] What will happen to the Land and Water Development Board remains to be seen, but it is likely that their functions will also be taken over by the new provinces. These political changes may make a number of administrative modifications possible, and may aid in the development of better coordination along the lines suggested by current technical assessments and administrative recommendations.

Coordination of water and other agricultural inputs can be facilitated in non-project areas through the decentralization of the former Irrigation and Agriculture Departments. In each of the new provinces the Planning and Development Departments can appoint commissions on Irrigation and Agriculture. These commissions can insist on coordination at the local level between the Departments before funds are allocated. This would be a simpler step now that new provinces are launched. The benefits from such a move could be significant. Coordination of water and other agricultural inputs in project areas now governed by the ADC and LWDB might also be taken over by the provinces.

The break up of the One Unit might lead to important coordination of all water in West Pakistan. This could be an ideal time to create one Indus Basin Water Authority. Such a new authority could receive requests for water from the new provincial Irrigation Departments and also from the Project Directors of the ADC. It could also be empowered to coordinate groundwater and surface water supplies. Either the water wing of the WAPDA, or a new top level entity composed of top personnel from WAPDA and the old Irrigation Department might well constitute such a new authority.

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[24] Pakistan Times, 24(June 5, 1970), 1, 11.

[25] Ibid., 24(Spril 2, 1970), 1.

[26] Ibid., 25(January 6, 1972), 1.

Coordination of public and private groundwater programs should become the new chief task of WAPDA. With major portions of the Indus Basin Project completed WAPDA can turn its major attention to the development of the groundwater. In order to better coordinate public and private tubewell fields, the tubewell drilling facilities of the old Agriculture Departments could be turned over to WAPDA.

The new water authority, WAPDA, could be autonomous bodies under the direct control of the President. The provincial Irrigation Departments could petition the new authority for water supplies. Funds might be obtained from their provincial Planning and Development Departments. Coordination between water and other agricultural inputs in non-project areas can be endorsed by the Planning and Development Departments before such funds are granted. With political support these important modifications in the water management system can be made. Such modifications would complete the "Era of Coordination," and create an increase in agricultural production.

Conclusion

The direction of reorganization in the water management system in West Pakistan has remained in progressive change since partition. Its chief goal has continued to be the maximization of agricultural production through the provision of adequate water supplies. However, because of technical, administrative and political constraints, this was not quickly accomplished. Instead, reorganization occurred incrementally and in a series of stages. During the Independence Era, the chief priority was tc continue and, if possible, to increase the supply of surface water previously provided under British rule. In the mobilization Era, there was amove for better organization of the nation's water and power resources for economic development via the creation of WAPDA. Finally, in the Era of Coordination, the project area approach to agricultural development was set up. The experience of West Pakistan in the administrative reorganization of the water management systems supports the first hypothesis of this paper, namely, that reorganization occurs in a series of stages.

The second hypothesis stated that reorganization is only successful when there is a technical, administrative, and political impetus for it. All three have been necessary before a viable reorganization occurred. Technical factors alone, such as the Indus Basin Project, or the need to coordinate water and other agricultural inputs were not sufficient to bring about successful structural and behavioral modification. Likewise, administrative suggestions, such as were contained in the Eggers report, accomplished little in the way of actual behavioral change unless effectively combined with technical assessments and a favorable political climate. Finally, even though the political sector has the power to bring about changes, only those based upon sound technical and administrative calculations will prove viable and lasting.

The lessons of West Pakistan's water management reorganization are very important for those interested in changing bureaucracies. First of all, it cannot be assumed that sudden changes will take place, even if there is apparent reason for it. Second, change agents must work with the changes arising spontaneously in the various sectors, and manipulate them to bring about the desired modifications. Although this task of reorganization is difficult and extremely complex, the initial successes already achieved in West Pakistan suggest that the efforts are well rewarded.

REORGANIZATION OF WATER MANAGEMENT AGENCIES - Part I

	Agencies	Technical Inputs	Administrative Inputs	Political Inputs
THE INDEPENDENCE ERA 1947-1958	Irrigation & Power Departments in State and Provinces 1947	Water Crisis with India 1948 (argued against new organizations)	British and Moghul patterns of Administration (argued against experiments in organization)	
	Merger of Agencies into Irrigation and Power Dept. of West Pakistan	Warsak High Dam construction. 1948 (called for a new agency to integrate water and power.		One Unit Scheme 1955. Called for one government Department.
		Indus Basin Plan Proposed 1951 (called for a new organization to build link canals and dams).	Egger's Report 1953 (called for Public Corporations to undertake development tasks).	
		Irrigation Dept-USGS Survey 1954. (Called for new agency to develop Groundwater).	Gladieux Report 1955. (seconded Egger's recommendation, incorporated into 5 year plan).	

REORGANIZATION OF WATER MANAGEMENT AGENCIES - Part II

	Agencies	Technical Inputs	Administrative Inputs	Political Inputs
THE MOBILIZATION ERA 1958-1970	Creation of West Pakistan Power and Water Development Authority (WAPDA) 1958			Military Take Over by Ayub Khan, 1958 (New Regime committed to use of public corporations.
	Agricultural Development Corporation established 1961.	Food and Agriculture Comcommission (FAC) 1960. Called for coordination of water and agriculture inputs in project areas.	FAC called for a public corporation to administer project areas.	
	Land and Water Development Board established in 1964	Revelle Report 1964. Called for Coordination of water and agriculture inputs in "Reclamation" project areas.	Revelle Report called for establishment of Land and Water Development Board (LWDB).	
		World Bank Study Group 1969 (called for coordination of surface and groundwater supplies.	World Bank called for new coordination Authority.	

REORGANIZATION OF WATER MANAGEMENT AGENCIES - Part III

	Agencies	Technical Inputs	Administrative Inputs	Political Inputs
THE COORDINATION ERA 1970-	Break up of Irrigation and Agriculture into Provincial Depts. 1971	Need for Coordination carried over by Food and Agriculture Commission (FAC) and Revelle Reports.		Breakup of One Unit, 1970. Elections, 1970.
			Need for new administrative strucutre in the new provinces.	
	Agriculture Development Corporation (ADC) dissolved in 1972 and functions given to provinces.			Creation of Bangla-Desh, and Inauguration of civilian government in Pakistan under Ali Bhutto.

Part I-3.

WATER MANAGEMENT AGENCIES: ORGANIZATIONAL CHARTS

Introductory Note

Maintaining a current record of the organizational changes in any central government is a major undertaking and requires that this activity be vested in a special agency. In Pakistan the publication of current organizational changes along with the issuance of organizational charts depicting these changes has never been a consistent program. Thus, organizational charts of the government and the major agencies are prepared by several agencies and often dated.

The organizational charts contained in this section are not up to date. However, it was felt that nevertheless they would be useful in providing a general indication of the organizational location as well as the structure of the principal water management agencies.

List of Organizational Charts

Figure 3-1

ORGANIZATION CHART
GOVERNMENT OF WEST PAKISTAN
1970—Prior to Dissolution of One Unit

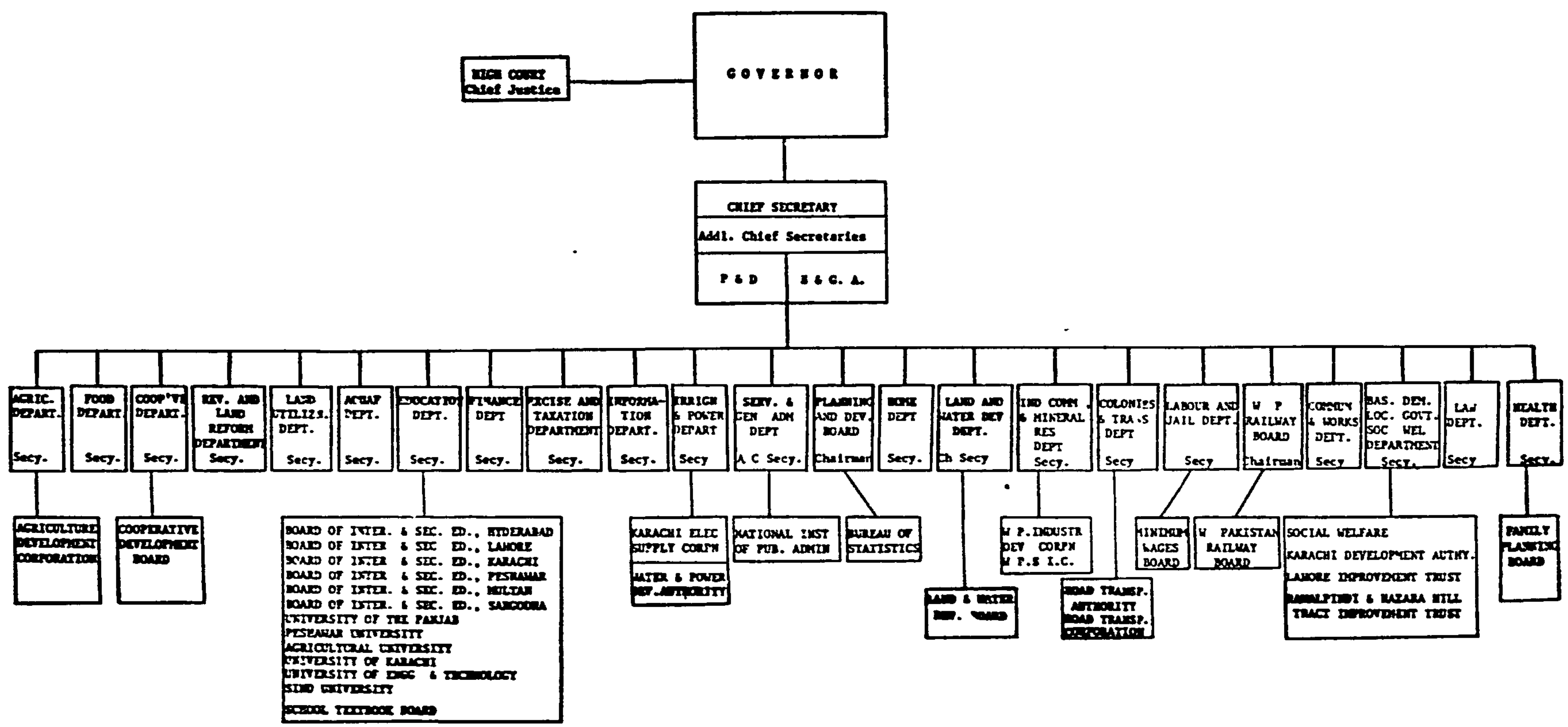


Figure 3-2

DEPARTMENT OF IRRIGATION AND POWER
1970--Prior to Dissolution of One Unit

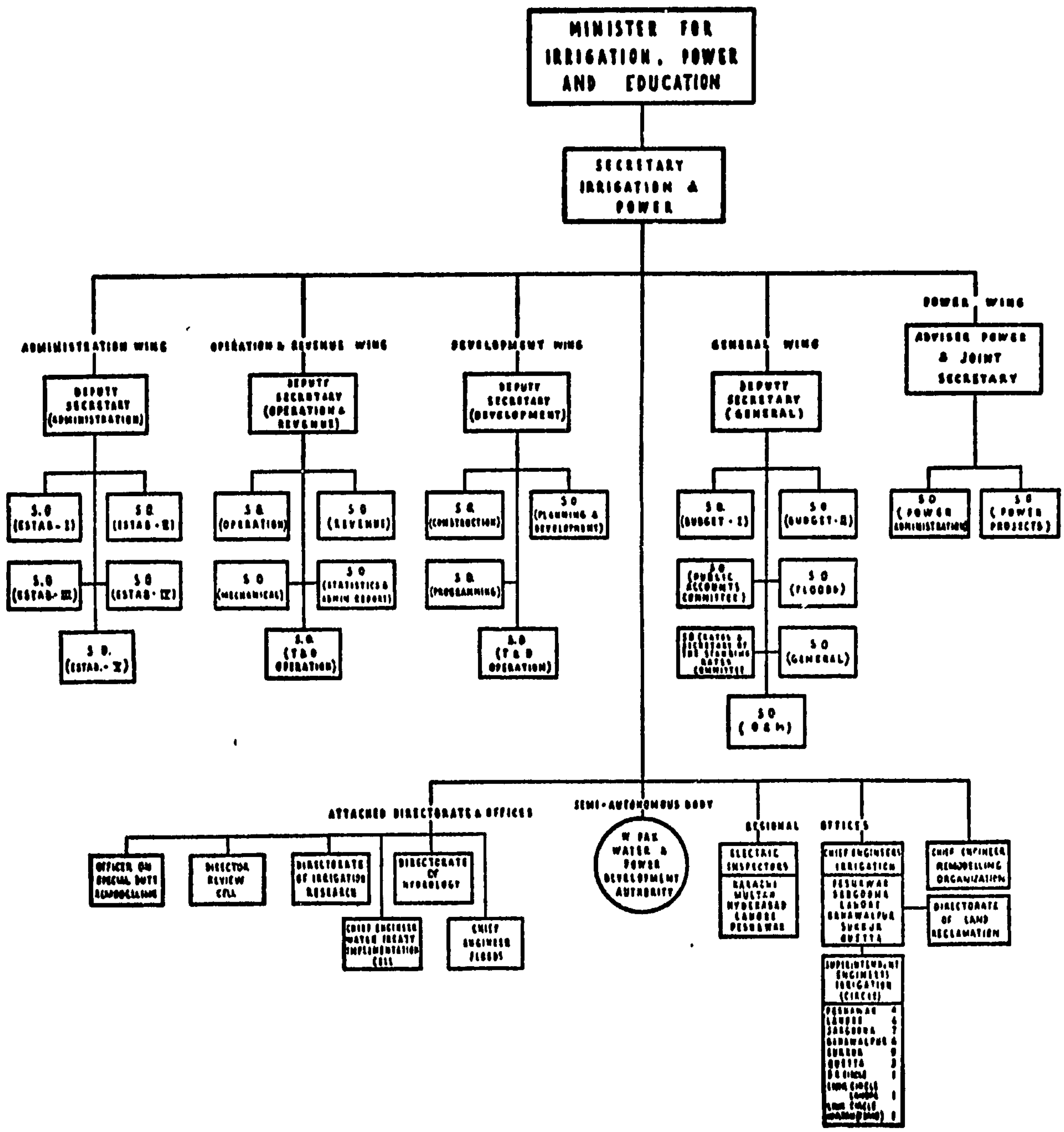


Figure 3-3

REGIONAL OFFICES--
DEPARTMENT OF IRRIGATION AND POWER
1970--Prior to Dissolution of One Unit

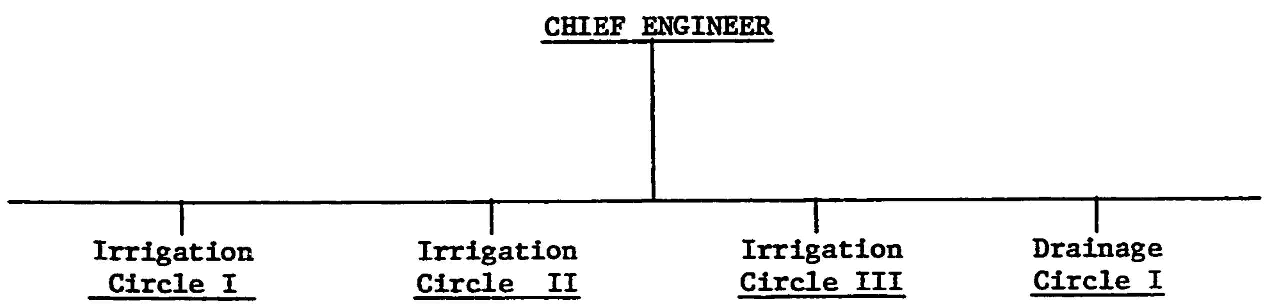


Figure 3-4

IRRIGATION CIRCLE
1970—Prior to Dissolution of One Unit

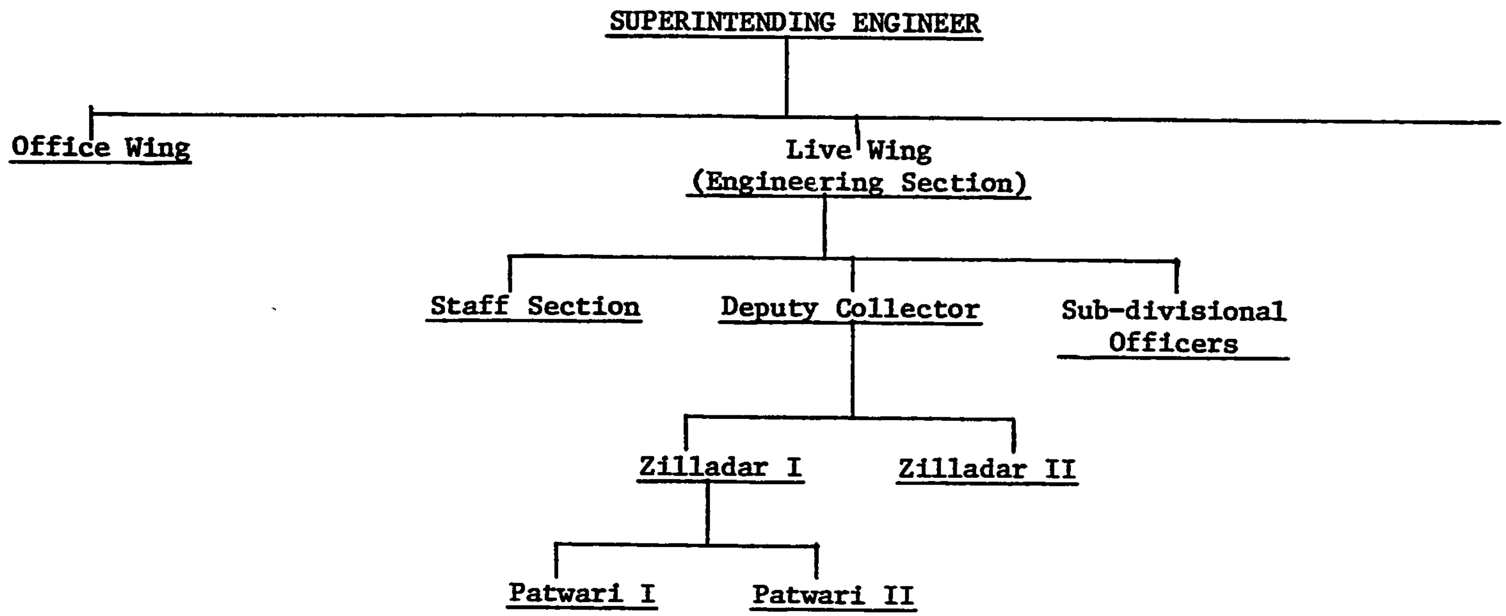


Figure 3-5

WEST PAKISTAN WATER AND POWER DEVELOPMENT AUTHORITY (WAPDA)
October 1969

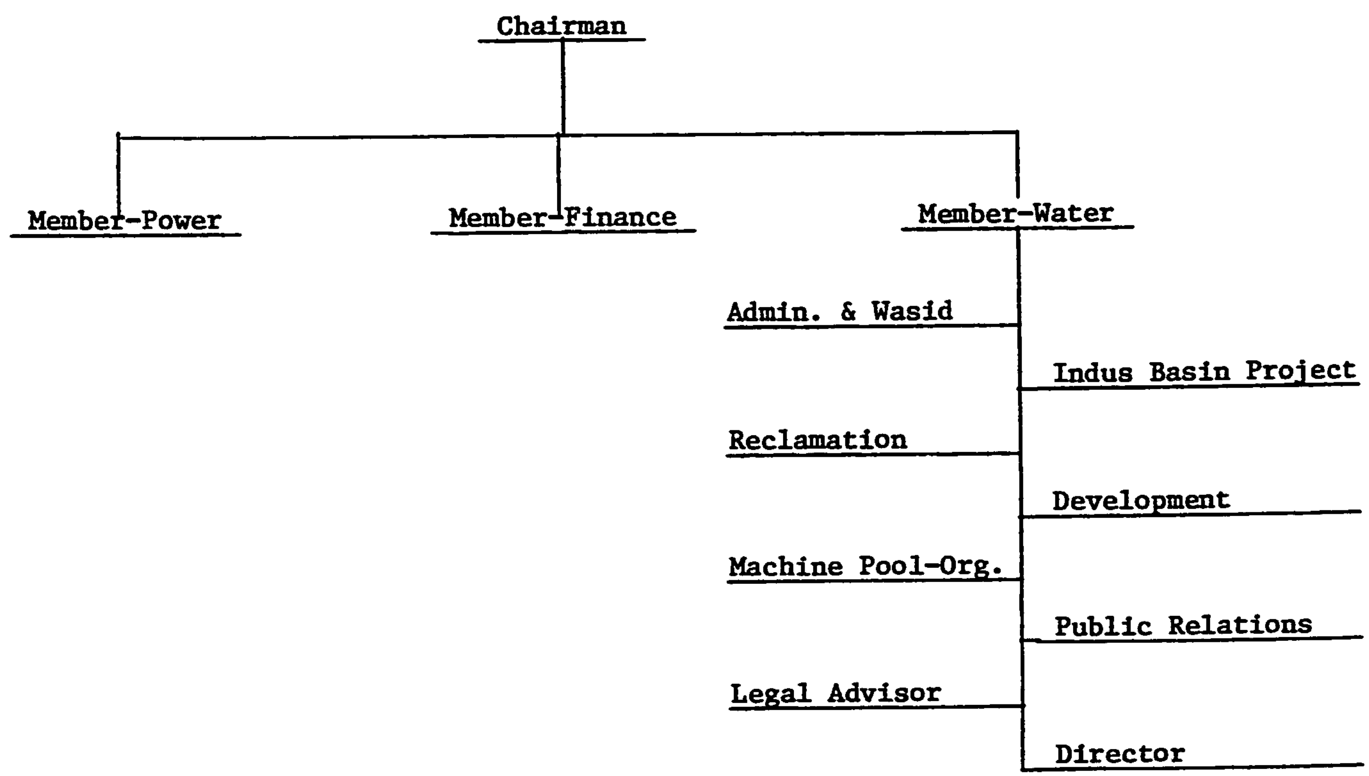


Figure 3-6

WAPDA's RELATIONSHIP TO WEST PAKISTAN GOVERNMENT
1970—Prior to Dissolution of One Unit

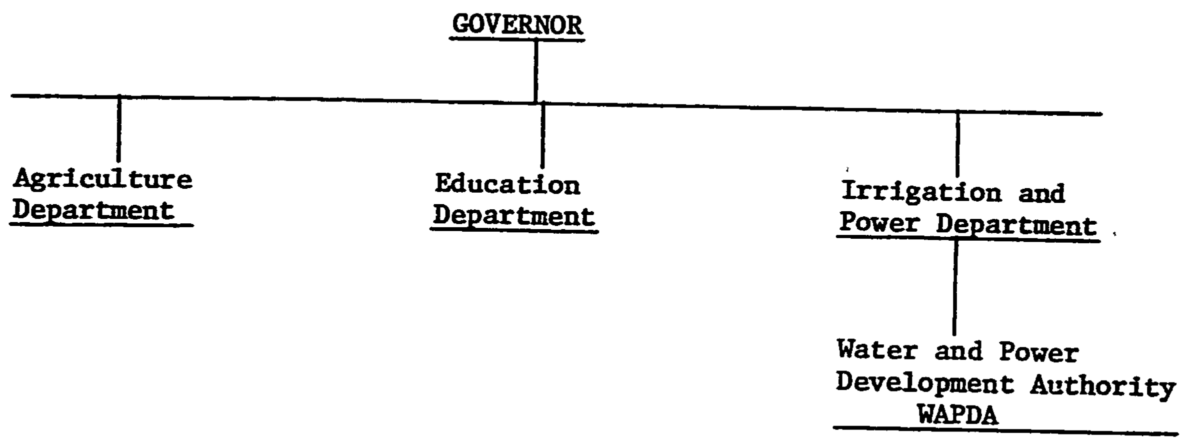


Figure 3-7

WAPDA's RELATIONSHIP TO CENTRAL GOVERNMENT IN REGARD
TO INDUS BASIN PROJECT
1970—Prior to Dissolution of One Unit

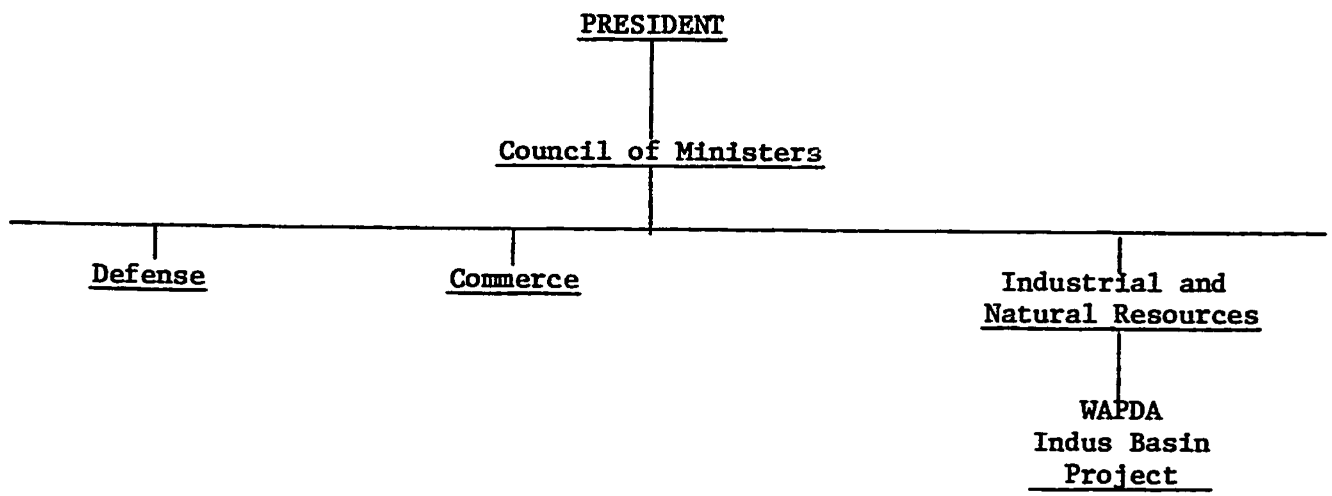


Figure 3-8

WEST PAKISTAN DEPARTMENT OF AGRICULTURE
1970

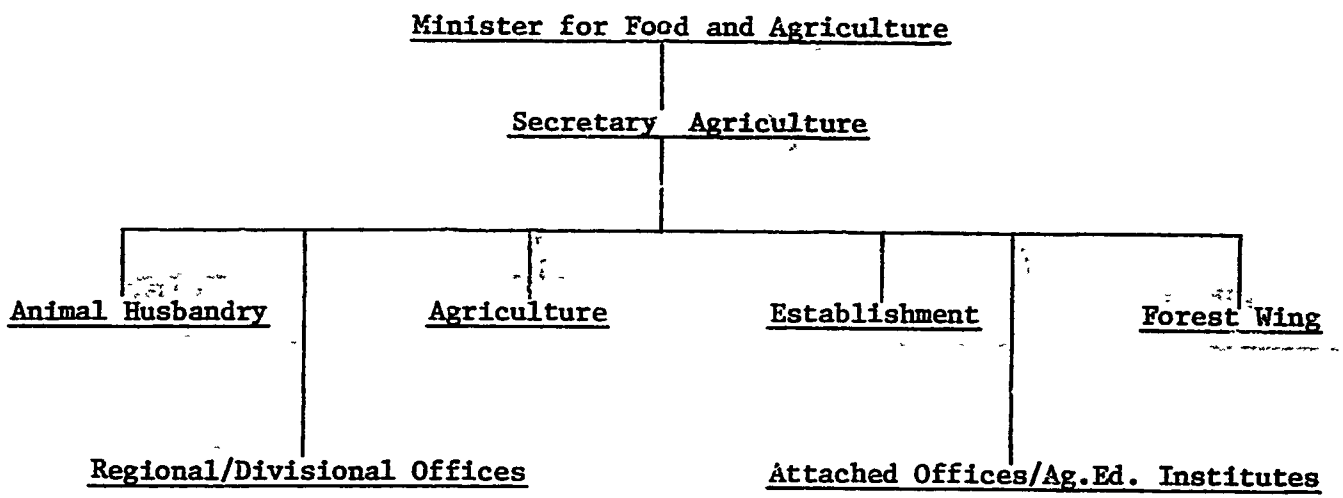


Figure 3-9

DEPARTMENT OF AGRICULTURE: WITH SPECIAL REFERENCE TO AGRICULTURE MACHINERY ORGANIZATION

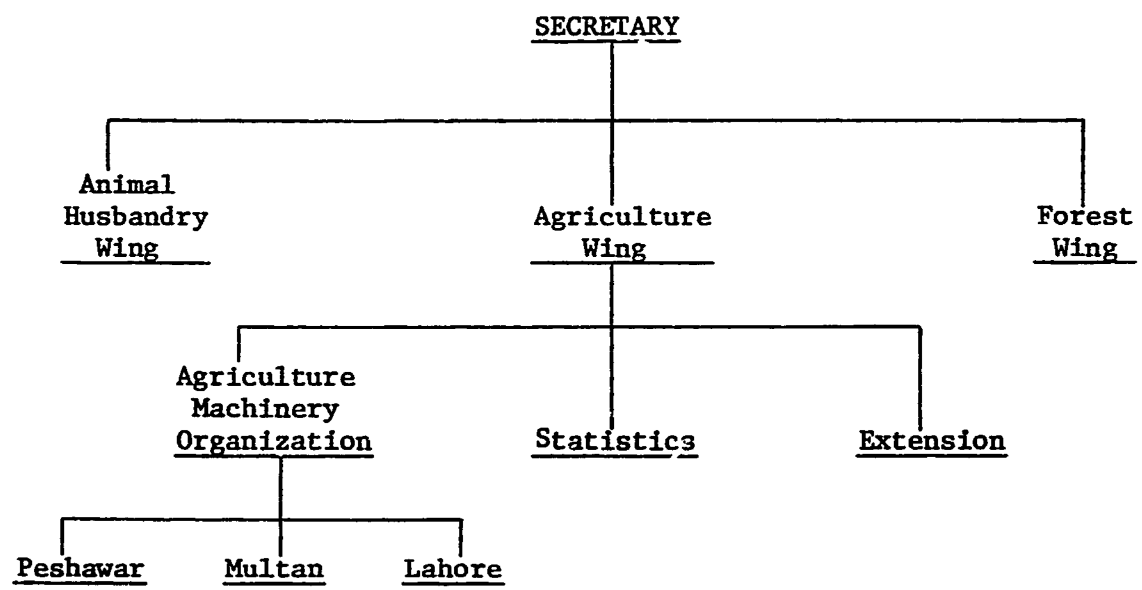


Figure 3-10

ORGANIZATION OF AGRICULTURAL EXTENSION STAFF
IN A REGION

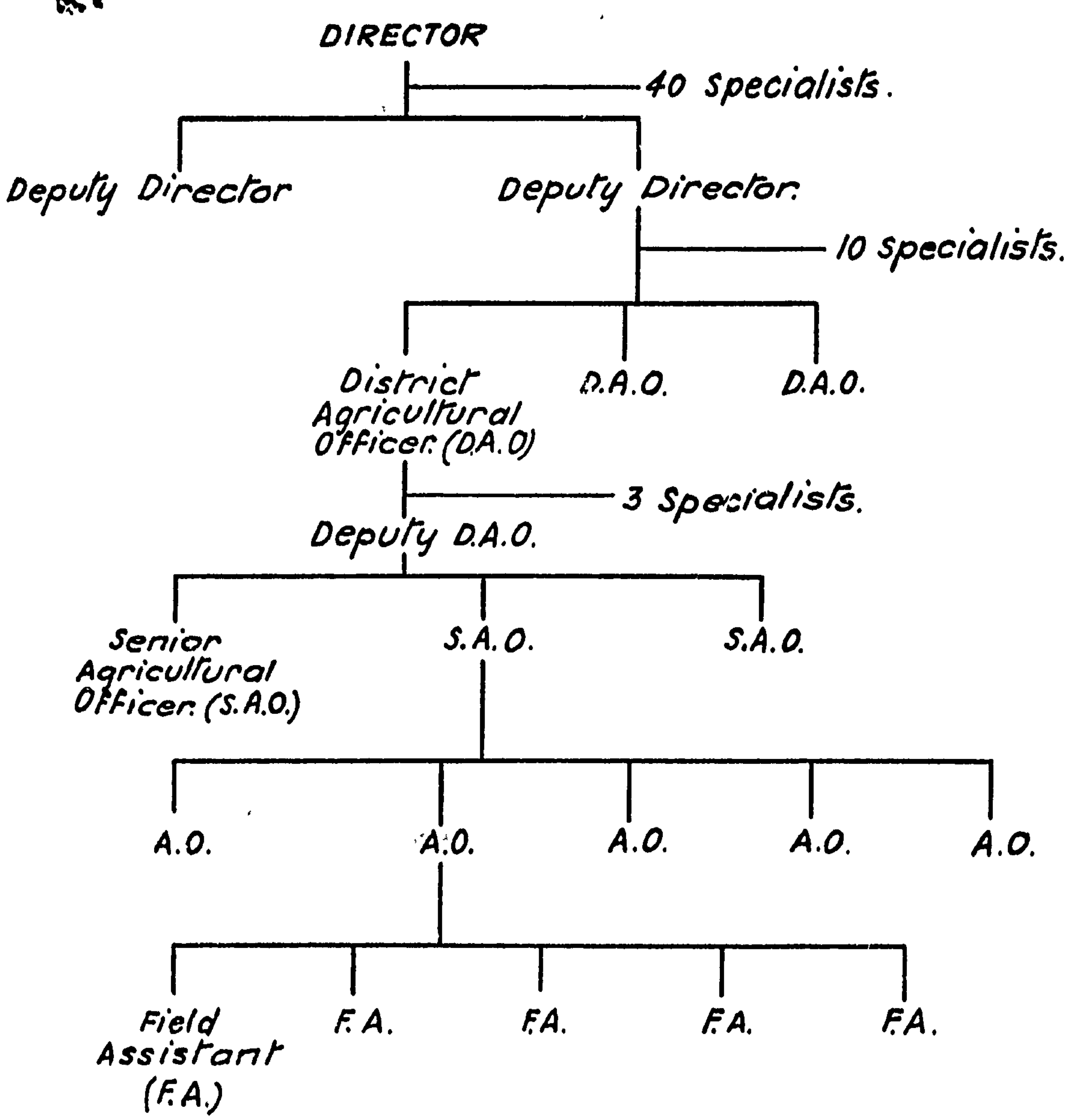
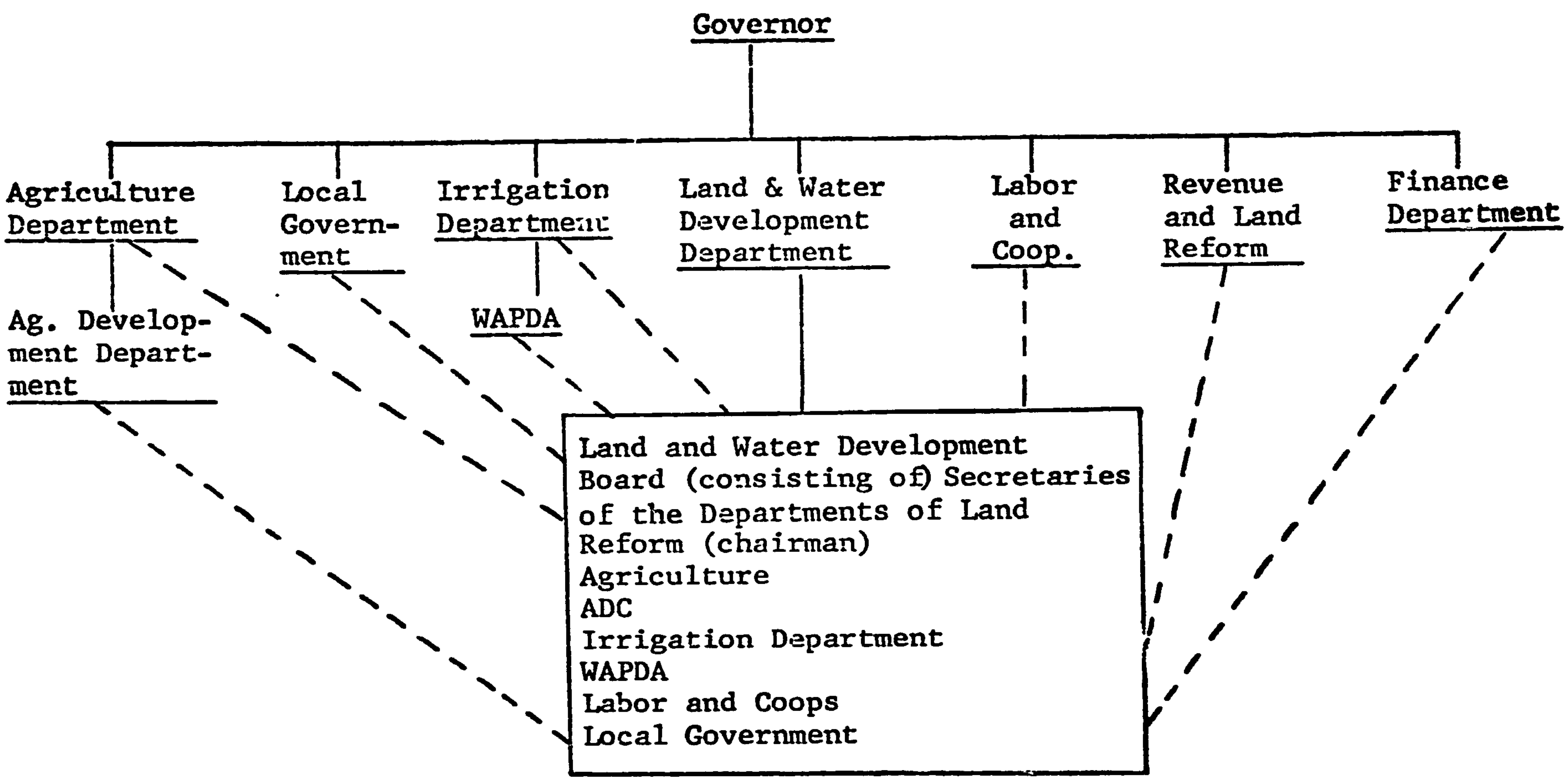


Figure 3-11

LAND AND WATER DEVELOPMENT BOARD
1970--Prior to Dissolution of One Unit



PART II: STATISTICAL DATA

6. Agricultural Development and Production

4. Water and Climate

Comprehensive data on the hydrology and climate of West Pakistan is found in:

Sir Alexander Gibb and Partners, International Land Development Consultants N.V., and Hunting Technical Services Limited, Programme for the Development of Irrigation and Agriculture in West Pakistan, prepared for the International Bank for Reconstruction and Development (London: Metcalfe and Co., 1966), volume 3, annexure 4, "Climate and Hydrology."

Much of the statistical data for section 4 is derived from this source.

The other principal source of data is Pieter A. Lieftinck, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources of West Pakistan, A Study in Sector Planning (Baltimore: The Johns Hopkins University Press for the World Bank, 1967), three volumes. This three volume study is largely a product of the 21 volume Gibb and others investigation of water planning problems and needs of West Pakistan, of which volume three is referenced above.

The following also constitutes a useful source of information: B. L. C. Johnson, South Asia, Selected Studies of the Essential Geography of India, Pakistan, and Ceylon (London: Heinemann Educational Books, Ltd., 1969).

Table 4.1 Water Development Potentials*

	Present	1975	1985	2000	Increase Percent
Rainfall	6	7	9	10	
Surface Water	58	63	77	91	50
Groundwater	10	30	40	44	340

*Lieftinck, Pieter, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources of West Pakistan, A Study in Sector Planning (Baltimore, Maryland: The Johns Hopkins University Press for the World Bank, 1967), Volume II, 63.

Table 4.2 River Basins*

	square miles
Kabul River above Attock	35,000
Indus River at Darband	64,000
Siran/Haro/Soan catchments	6,000
Jhelum River at Mangla	13,000
Chenab River at Alexandria Bridge	13,000
Gomal River at Kot Murtaza	14,000

*Sir Alexander Gibb and Partners, International Land Development Consultants N.V., and Hunting Technical Services Limited, Programme for the Development of Irrigation and Agriculture in West Pakistan, prepared for the International Bank for Reconstruction and Development (London: Metcalfe and Co., 1966), volume 3, annexure 4, "Climate and Hydrology."

Table 4.3 Annual and Ten Year Mean Flows of Indus River At Attock (MAF)*

1868-78	1878-88	1888-98	1898-1908	1908-18	1918-28	1928-38	1938-48	1948-58
89-91	92-62	95-51	81-51	90-59	101-31	88-82	104-94	96-78
91-02	78-98	81-04	91-63	103-89	85-61	106-33	83-95	101-17
89-45	76-71	87-01	81-72	109-75	93-72	90-05	89-35	72-40
90-04	96-14	78-23	68-62	90-79	107-26	94-44	106-15	88-05
82-11	81-64	81-65	80-33	83-49	99-44	98-04	97-03	88-62
100-56	92-44	100-30	78-50	98-78	109-61	92-77	87-25	94-08
85-40	97-92	76-82	92-47	97-07	87-03	92-68	99-21	82-41
104-68	96-23	95-08	101-75	89-50	88-52	98-40	86-89	99-43
78-78	83-01	102-79	76-66	80-89	77-63	87-93	78-67	86-62
136-06	77-19	96-63	105-62	83-55	96-79	98-08	85-32	95-15
Total								
947-91	872-88	895-06	858-81	928-30	946-92	947-54	918-76	904-71
Mean								
94-79	87-29	89-51	85-89	92-83	94-69	94-75	91-88	90-47

Note: The years at the column heads refer to the water years (i.e. from 1st October to 30th September).

*Gibb and others, Annexure 4. Reference noted under Table 4.2.

Table 4.33*

Average Annual Discharge of the Indus, Jhelum, and Chenab Rivers, 1922-1963 (MAF)

		Discharge		
River	Location	Mean	Minimum	Maximum
Indus	Attock	93	72	110
Jhelum	Mangla	23	15	33
Chenab	Marala	26		
		142		

*Lieftinck, Pieter, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources of West Pakistan, A Study in Sector Planning (Baltimore, Maryland: The Johns Hopkins University Press for the World Bank, 1968), Volume I, 39.

Table 4.4 Years of Damaging Floods 1922-1962*

Year	River in Flood	Discharge Cusecs	Year	River in Flood	Discharge Cusecs
1924	Indus	644,000	1953	Jhelum	311,000
1928	Jhelum	601,000		Chenab	316,000
	Chenab	686,000	1954	Chenab	320,000
1929	Indus	1,000,000		Ravi	141,000
	Jhelum	760,000	1955	Chenab	344,000
	Chenab	718,000		Ravi	542,000
1931	Jhelum	355,000		Sutlej	687,000
1932	Chenab	332,000	1956	Jhelum	303,000
1933	Chenab	366,000	1957	Chenab	1,100,000
1936	Ravi	107,000		Ravi	188,000
1942	Chenab	302,000	1958	Indus	633,000
	Ravi	130,000		Jhelum	730,000
1943	Ravi	101,000		Chenab	478,000
1947	Ravi	225,000		Ravi	140,000
	Sutlej	425,000	1959	Jhelum	811,000
1948	Jhelum	441,000		Chenab	871,000
	Chenab	432,000		Ravi	200,000
1950	Chenab	541,000	1960	Chenab	599,000
	Ravi	193,000	1961	Ravi	100,000
	Sutlej	400,000	1962	Ravi	132,000
1951	Sutlej	360,000			

*Gibb and others, Annexure 4. Reference noted under Table 4.2.

Table 4.5 Estimated Flood Losses 1948-1964*

	DIRECT LOSSES IN RS. MILLION				INTANGIBLE LOSSES		
Year	Private Property	Irrigation	Government Property Transportation	Total W. Pakistan	Lives Lost	Villages Affected	Area Flooded Square Miles
1948	48-96	7-50	0-25	56-71	151	2,231	2,914
1949	nil	nil	nil	nil	nil	nil	nil
1950	184-57	7-42	8-01	200-00	1,910	10,000	7,000
1951	52-48	8-54	1-26	62-28	25	893	2,155
1952	7-75	6-14	0-77	14-66	nil	39	34
1953	0-01	6-89	0-53	7-43	nil	261	36
1954	49-11	7-10	1-06	57-27	630	3,747	5,000
1955	157-41	17-61	4-85	179-87	679	6,945	8,000
1956	121-93	23-68	9-84	155-45	160	11,609	29,065
1957	97-41	40-68	14-21	152-30	83	4,498	6,261
1958	31-05	10-00	11-53	52-58	90	2,459	6,863
1959	73-19	15-00	12-17	100-36	88	3,903	4,702
1960	3-11	15-99	6-11	25-21	11	1,278	1,378
1961	58-25	8-99	5-20	72-44	22	2,114	1,861
1962	22-52	6-16	5-10	33-78	13	616	600
1963	2-55	n/a	n/a	2-55	3	478	175
1964	138-65	n/a	n/a	138-65	262	3,382	2,500
Total	1,048-95	181-70	80-89	1,311-54	5,127	—	—

*Gibb and others, Annexure 4. Reference noted under Table 4.2.

4.6 Estimated Flood Damage 1948-1962*

	Ravi		Chenab		Indus, Sutlej and Jhelum		Total	
	15-year Total	Annual Average	15-year Total	Annual Average	15-year Total	Annual Average	15-year Total	Annual Average
Private Property								
Crops and Produce	190.0	12.7	59.6	4.0	276.8	25.1	627.2	41.8
Housing	111.0	7.3	64.9	4.3	104.8	7.0	280.7	18.6
Cattle	9.5	0.6	3.2	0.2	2.5	0.2	15.2	1.0
Subtotal	310.5	20.6	127.7	8.5	384.1	32.3	923.1	61.4
Public Installations								
Irrigation Works	31.9	2.1	14.6	1.0	134.2	8.9	180.7	12.0
Roads and Bridges	8.5	0.6	6.8	0.5	38.7	2.5	54.0	3.6
Railway Facilities	12.6	0.9	13.8	0.9	10.8	0.7	37.2	2.5
Subtotal	53.0	3.6	35.2	2.4	183.7	12.1	271.9	18.1
Total	363.5	24.2	162.9	10.9	467.8	44.4	1,195.0	79.5

*Lieftinck and others, 93. Reference noted under Table 4.1.

Table 4.7 Flood Magnitudes of Punjab Rivers (cusecs)*

Location	5-year Flood	10-year Flood	50-year Flood
Indus at Attock	530,000	570,000	650,000
Jhelum at Mangla	360,000	520,000	1,100,000
Chenab at Marala	480,000	660,000	1,400,000
Ravi at Shahadara	130,000	160,000	230,000
Sutlej at Ferozepore	400,000	470,000	650,000

*Gibb and others, Annexure 4. Reference noted under Table 4.2.

Table 4.8 Summary of Sediment Transport **

River	Location	Catchment Area sq. mi.	Mean Runoff MAF/yr.	Sediment Transport Short Tons/yr.	Erosion ac. ft./ sq. mi.
Gilgit	Gilgit	4,700	7-0	10-0 million	1-2
Indus	Partab Br.	58,000	47	177	1-6
Indus	Darband	64,000	65	440*	3-0
Indus	Kalabagh	112,000	97	540	2-1
Kabul	Warsak	26,000	15	52	1-1
Kabul	Nowshera	34,000	33	70	1-1
Swat	Kalam	780	2-2	0-29	0-19
Swat	Chakdara	2,200	4-0	1-40	0-38
Bara	Jhansi	710	0-22	1-9	1-5
Kalpani	Risalpur	1,000	0-72	3-8	2-0
Siran	Thapla Br.	1,000	0-75	2-8	1-4
Haro	Khanpur	300	0-22	0-83	1-5
Haro	Sanjwal	700	0-44	7-1	5-9
Soan	Chirah	130	0-12	2-6	12
Soan	Rawalpindi	650	0-50	4-4	3-9
Kunhar	Naran	400	1-2	0-24	0-34
Kunhar	Khanian	580	1-7	0-42	0-42
Kunhar	Garhi Habibullah	920	2-5	5-8	3-9
Kishanganga	Muzaffarabad	2,800	10	6-0	1-0
Bishan Daur	Missa	60	0-01	0-2	1-9
Ling	Kabuta	60	0-06	0-13	1-3
Kanshi	Jhangi	460	0-15	5-1	6-4
Jhelum	Mangla	13,000	23	72	3-0
Chenab	Alexandria Br.	13,000	17-0	63-0	2-6
Kohat Toi	Jarma Weir	600	0-06	1-0	0-9
Gomal	Kot Murtaza	14,000	0-35	29	1-3
Beji	Ghatti Br.	6,400	0-13	3-2	0-3
Nari	Sibi	8,400	0-44	20	1-5
Hub	Murad Khan	3,600	0-4	3-6	0-5

*All figures are for suspended sediment with the exception of Darband and Kalabagh which include bed load estimated to be 5% of the total. Table based on data obtained during period 1960 to 1964.

**Gibb and others, Annexure 4. Reference noted under Table 4.2.

Table 4.9 Computed Evaporation and Effective Rainfall (in inches--rainfall in parentheses)*

	North	South
Winter (October to March)	18 (3.6)	27 (0.8)
Summer (April to September)	41 (15.6)	49 (2.6)
Annual Total	59 (19.2)	76 (3.4)

*Lieftinck and others, 35. Reference noted under Table 4.33.

5. IRRIGATION DEVELOPMENT AND OPERATIONS

Table 5.1 Mean-Year Storage Surplus Based on IACA's Projected Program: Jhelum River at Mangla (MAF)*

		1985		Full Development	
Month	Mean Flow at Mangla[a]	Irrigation Requirements[b]	Storable Surplus	Irrigation Requirements	Storable Surplus
May	3.6	0.8	2.8	2.1	1.5
June	3.7	0.7	3.0	1.8	1.9
July	3.8	0.6	3.2	1.1	2.7
Aug.	3.0	0.8	2.2	1.6	1.4
Sept.	1.6	1.0	0.6	2.0	*
Total	15.7	3.9	11.8	8.6	7.5

[a]41-year period, 1922-1963
[b]After full allowance is made for use of flows from the Chenab River
*Storage release

*Lieftinck and others, 120. Reference noted under Table 4.33.

Table 5.2 Mean Year Storable Surplus Based on IACA's Projected Program: Indus River at Tarbela (MAF)*

		1985		Full Development	
Month	Mean Flow at Darband[a]	Irrigation Requirements[b]	Storable Surplus	Irrigation Requirements	Storable Surplus
May	4.4	3.1	1.3	6.0	*
June	10.2	5.0	5.2	9.4	0.8
July	16.8	1.5	15.3	5.7	11.1
Aug.	16.0	2.4	13.6	6.1	9.9
Sept.	6.8	4.5	2.3	6.6	0.2
Total	54.2	16.5	37.7	33.8	22.0

[a]41-year period, 1922-1963
[b]After full allowance is made for use of flows from the Kabul River
*Storage release

*Lieftinck and others, 120. Reference noted under Table 4.33.

Table 5.3* Average Annual Yield and Efficiency of Storage Capacity on the Indus and Jhelum Rivers at the Ultimate Stage of Development[a]

Storage Capacity	Average Annual Yield (MAF)		Efficiency of Storage Capacity (Percent)	
(MAF)	Indus at Darband	Jhelum at Mangla	Indus at Darband	Jhelum at Mangla
1	1.0	1.0	100	100
2	2.0	2.0	100	100
3	3.0	2.9	100	97
4	4.0	3.8	100	95
5	5.0	4.6	100	92
6	6.0	5.4	100	90
7	7.0	5.9	100	84
8	8.0	6.4	100	80
9	9.0	6.6	100	73
10	10.0	6.7	100	67
15	15.0	b	100	b
20	19.5	b	98	b
25	21.8	b	87	b
30	22.5	b	75	b
35	22.6	b	64	b

[a]Assuming the year 2000 mean-year irrigation requirements as estimated by IACA continue to be met during the impounding season.

[b]Not physically feasible to provide capacity of this size on the Jhelum.

*Lieftinck and others, 122. Reference noted under Table 4.33.

Table 5.4 Canal Irrigated Area and Other Areas (1965-66)*

Thousand Acres

Drop	Canal irrigated	Remainder	Total cropped area
Total Food Crops	18.05	11.17	29.22
of which: Wheat	7.72	4.99	12.71
Rice	3.52	-	3.52
Cotton	3.71	-	3.71
Fodder	4.99	1.20	6.19
Total crops(1)	26.75	12.37	39.12

(1)These statistics slightly differ from those given in Table 14 in the Appendix which were provided by the Irrigation Department.

Source: International Agriculture Consultants Association Comprehensive Report.

*Kahnert, F., R. Carmignane, H. Stier, and P. Thomopoulos, Agriculture and Related Industries in Pakistan, Paris: OECD (Organization for Economic Co-Operation and Development), Development Centre, 1970, 109.

Table 5.5*

AVERAGE ANNUAL IRRIGATION WITHDRAWALS
FROM RIVERS IN WEST PAKISTAN

1947/48 TO 1965/66

(MAF at canal head)

	Kharif	Rabi	Total
1947/48-1950/51	44.4	20.7	65.1
1951/52-1955/56	51.3	22.8	74.1
1956/57-1960/61	52.4	27.0	79.4
1961/62-1965/66	57.6	27.2	84.8

*Lieftinck and others, 10. Reference noted under Table 4.33.

Table 5.6*

APPROXIMATE INDICATION OF ANNUAL WATER SUPPLIED AVAILABLE
According to Regional Areas

	Acre-Feet per Cropped Acre	
	1965 Condition	Ultimate
Bari Doab	2.0	3.0
Sutlej/Panjnad Left Bank	2.2	3.4
Rechna Doab	2.3	2.6
Chaj Doab	1.8	2.6
Thal and Indus Right Bank	2.7	2.8
Peshawar and Swat	1.8	2.3
Lower Indus (Sind)	2.9	3.5

*Lieftinck and others, 24. Reference noted under Table 4.33.

Table 5.7*

MONTHLY DISTRIBUTION OF WATERCOURSE SUPPLIES BY SOURCES
(Mean-year flows--1985 conditions)

	Surface Water		Tarbela		Groundwater		Total	
Month	MAF	Percent Per Month	MAF	Percent Per Month	MAF	Percent Per Month	MAF	Percent Per Month
October	6.1	54.5	--	0.0	5.1	45.5	11.2	9.6
November	2.3	41.1	0.4	7.1	2.9	51.8	5.6	4.8
December	2.1	44.7	0.5	10.6	2.1	44.7	4.7	4.0
January	2.0	35.7	0.9	16.1	2.7	48.2	5.6	4.8
February	3.0	34.9	1.1	12.8	4.5	52.3	8.6	7.4
March	3.9	44.8	0.9	10.4	3.9	44.8	8.7	7.5
April	5.1	73.9	0.5	7.3	1.3	18.8	6.9	5.9
May	7.1	78.9	--	0.0	1.9	21.1	9.0	7.7
June	10.0	74.6	--	0.0	3.4	25.4	13.4	11.5
July	9.3	71.5	--	0.0	3.7	28.5	13.0	11.2
August	10.2	65.8	--	0.0	5.3	34.2	15.5	13.3
September	9.0	62.9	--	0.0	5.3	37.1	14.3	12.3
	70.1		4.3		42.1		116.5	100.0

*Lieftinck and others, 133. Reference noted under Table 4.33.

Table 5.8*

CCA, CROPPING INTENSITIES, WATERCOURSE DELIVERIES[a] AND WATER APPLICATION

Region	CCA (mill. of acres)	Cropping Intensity (%)	Current (1965) Status: Annual Water-course Supplies (MAF)	Current (1965) Status: Acre-Feet Per Cropped Acre	For Full Delta At 150% Intensity: Annual Water-course Supplies (MAF)	For Full Delta At 150% Intensity: Acre-Feet Per Cropped Acre
Peshawar and Swat	0.7	135	1.7	1.8	2.8	2.3
Bari Doab	5.8	102	12.1	2.0	26.0	3.0
Rechna Doab	4.7	106	11.2	2.3	18.0	2.6
Chaj Doab	2.0	104	3.8	1.8	8.0	2.6
Sutlej/Panjnad L.B.	3.5	92	7.0	2.2	18.0	3.4
Thal/Indus R.B.	3.6	64	6.3	2.7	15.0	2.8
Sind	13.2	67	25.6	2.9	47.0	3.5
	33.5[b]		67.7		134.8	

[a]Includes surface and groundwater deliveries.
[b]Only 25 million acres currently receive canal supply.

*Lieftinck and others, 35. Reference noted under Table 4.1.

Table 5.9*

RELATIVE USE OF SURFACE AND GROUNDWATER
MEASURED AT WATERCOURSE HEAD

Reference Year	Surface Water		Groundwater		Total MAF
	MAF	Percent	MAF	Percent	
1965	58	85	10	15	68
1970[a]	56	75	19	25	75
1975	63	68	31	32	94
1985	77	66	40	34	117
2000	91	67	44	33	135

[a]The estimate for 1970 was derived from sequential analysis data, with some adjustment for surpluses occurring during rabi period and the effect of the adopted pumping pattern (including pumping needed for lowering of water table in project areas) on surface water use.

*Lieftinck and others, 109. Reference noted under Table 4.33.

Table 5.10*

WATERCOURSE DELIVERIES TO THE MAIN SECTORS
OF THE INDUS BASIN
(MAF/Year)

Reference Year	Vale of Peshawar		Punjab		Sind		Total (rounded) MAF
	MAF	Percent	MAF	Percent	MAF	Percent	
1965	1.7	2.5	40	59.5	26	38	68
1975	1.9	2	61	65	31	33	94
1985	2.8	2.5	75	64	39	33.5	117
2000	2.8	2	85	63	47	35	135

*Lieftinck and others, 111. Reference noted under Table 4.33.

Table 5.11*

DEPTH TO GROUNDWATER IN CANAL-COMMANDED AREAS
(million acres)

	Usable Groundwater (0-3,000 ppm)		Saline Groundwater (above 3,000 ppm)	
	Less than 10 feet	More than 10 feet	Less than 10 feet	More than 10 feet
Punjab	6.1	8.6	1.2	2.6
Sind	1.1	1.2	3.9	2.9
Total (excl. Peshawar)	7.2	9.8	5.1	5.5

*Lieftinck and others, 43. Reference noted under Table 4.33.

Table 5.12*

HARZA ESTIMATE OF GROUNDWATER RECHARGE IN WEST PAKISTAN

Usable Groundwater	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 Groundwater	3.5	14.3	17.8
Total	37.9	21.8	59.7

*West Pakistan University of Engineering and Technology, "A Study of the Contribution of Private Tubewells in the Development of Water Potential in Pakistan," Lahore: West Pakistan University of Engineering and Technology for Planning Commission, Government of Pakistan (Islamabad), June 1970, 8 (offset).

Table 5.13*

REGIONAL GROUNDWATER QUALITY ZONE AREAS
(million acres of development CCA)

Region	Fresh	Mixing	Saline	Total
Vale of Peshawar	0.48	0.10	--	0.68
Thal Doab and Indus Right Bank	2.03	0.99	0.60	3.62
Chaj Doab	1.19	0.36	0.49	2.04
Rechna Doab	3.37	0.84	0.49	4.70
Bari Doab	3.95	1.34	0.54	5.83
Sutlej and Panjnad Left Bank	1.29	0.47	1.75	3.51
Lower Indus	1.81	0.45	6.72	8.98
Total	14.22	4.55	10.59	29.36

*Lieftinck and others, 49. Reference noted under Table 4.33.

Table 5.14*

RATE OF GROUNDWATER DEVELOPMENT
(MAF/year)

	1965	1975	1985	2000
Private Tubewells (in CCA)	5.3	7.0	3.5	--
Public Tubewells	2.7	22.0	36.5	44.0
Persian Wheels	1.7	1.0	--	--
Total in CCA:	9.7	30.0	40.0	44.0
Private Tubewells Outside CCA	1.0	2.8	5.0	6.5
Total	10.7	32.8	45.0	50.5

*Lieftinck and others, 75. Reference noted under Table 4.1.

Table 5.15*

SELECTED PROJECTIONS OF PRIVATE TUBEWELL GROWTH
(number of wells)

	1965	1970	1975	1985
Dipalpur above BS Link (Bari)	860	1840	2470	3115
Rohri North (Sind)	100	300	800	1600
Panjnad-Abbasia (Sutlej Left Bank)	615	1990	3230	4570

*Lieftinck and others, 57. Reference noted under Table 4.33.

Table 5.16*

PUBLIC AND PRIVATE TUBEWELL DEVELOPMENT

Number of wells installed per year

Item	1965-66	1966-67	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75
Public Sector										
Deep Tubewells (WAPDA)[1]	380	820[5]	1,680[5]	2,128[3]	2,079	2,100	2,350	2,290	1,990	2.315
on-going programme	380	820	1,680	1,933	1,430	905	600	450		
new IACA revised programme	-	-	-	195	649	1,195	1,750	1,840	1,990	2,315
Irrigation Development Tubewells[2]	90	300	350	400[4]	500	500	500	500	500	500
Private Tubewells										
new tubewells										
-diesel	3,400	5,400	6,000	6,000	6,000	3,000	2,000	1,000	1,000	1,000
-electric	3,200	5,100	4,500	4,500	4,500	6,000	6,000	3,000	2,500	2,500
replacement										
-diesel			500	1,500	2,000	1,500	1,500	1,500	1,500	1,500
-electric			500	1,500	2,000	1,500	1,500	2,000	2,000	2,000

(1) According to the IBRD/IACA programme including replacement at the end of the period; (2) Estimates; (3) The number of deep tubewells to be installed in 1968-69 was estimated in the 1968-69 Annual Plan at only 1,600; (4) As given in the 1967-68 Annual Plan; (5) Actuals were 230 in 1965-66, 1,155 in 1966-67 and 1,628 in 1967-68. Source: OECD Development Centre estimates, unless otherwise mentioned in footnotes.

*Kahnert, F., R. Carmignani, H. Stier, and P. Thomopoulos, Agriculture and Related Industries in Pakistan, Paris: OECD (Organisation for Economic Co-Operation and Development), Development Centre, 1970, 117.

Table 5.17*

ACTION PROGRAM FOR PUBLIC GROUNDWATER DEVELOPMENT
DURING THIRD PLAN
(number of wells installed)

	1966/67	1967/68	1968/69	1969/70
SCARP II	420	590	615	580
SCARP III	270	520	465	215
SCARP IV	50	370	565	635
Khairpur	80	200	288	
Wagah			95	
Shorkot-Kammalia			100	326
Rohri North				140
Panjnad Abbasia				183
Total Wells	820	1,680	2,128	2,079

*Lieftinck and others, 85. Reference noted under Table 4.33.

Table 5.18*

SCHEDULE OF IMPLEMENTATION FOR THE ONGOING
PUBLIC TUBEWELL PROJECTS
(numbers of wells completed)

Project	1966/67	1967/68	1968/69	1969/70	1970/71	1971/72	Total
SCARP II	420	630	418	307	100	-	1,875
SCARP III	240	570	495	165	-	-	1,470
SCARP IV	110	500	780	790	745	345	3,270
Khairpur	80	200	288	-	-	-	568
Total	850	1,900	1,981	1,262	845	345	7,183

*Lieftinck and others, 85. Reference noted under Table 4.33.

Table 5.19*

DELIVERY CAPACITY OF SCARP (WAPDA) TUBEWELLS IN 1969

Project	Tubewells Installed		Tubewells in Operation	
	Number	Capacity (cfs)	Number	Capacity (cfs)
SCARP I	2,058[a]	6,000	2,058[a]	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[a]	23,012	4,405[a]	14,852

[a]In SCARP I, 262 tubewells installed by the Irrigation Department are also included.

*West Pakistan University of Engineering and Technology, "A Study of the Contribution of Private Tubewells in the Development of Water Potential in Pakistan," Lahore: West Pakistan University of Engineering and Technology for Planning Commission, Government of Pakistan (Islamabad), June 1970, 46 (offset).

Table 5.20

SUMMARY NARRATIVE OF TUBEWELL DEVELOPMENT, WEST PAKISTAN, 1969*

1. In 1969 there were 87,752 tubewells: 79,233 private tubewells and 8,519 public tubewells.

2. 48,520 of the private tubewells or 61 percent were run by diesel engines and 30,713 or 39 percent tubewells by electric motors.

3. 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.

4. 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.

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

6. 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.

7. 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.

8. 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

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*Adapted from "A Study of the Contribution of Private Tubewells in the Development of Water Potential in Pakistan," Lahore: West Pakistan University of Engineering and Technology for Planning Commission, Government of Pakistan (Islamabad), June 1970, 114-119 (offset).

year for holding of less than 10 acres to 3,500 hours per year for holdings of 200 acres or more.

9. The average delivery capacity of a private tubewell is about one 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 about 82,179 cusec.

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

15. 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.

16. Tubewells stimulate development of local industry in pipes, pumps, motors, engines, and strainers and provide employment opportunities for the people.

17. 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.

18. Sixty percent of the private tubewells are 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.

19. 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.

20. 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.

21. 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.

22. 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.

23. 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.

24. Tubewells help stimulate the use of agricultural inputs such as fertilizers, improved seeds and plant protection thus laying a sound basis for commercial agriculture.

25. 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.

26. 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.

27. The rate of installation of private tubewells has been declining since 1966.

Table 5.21*

TOTAL CONTROLLED WATER AVAILABILITY

MAF measured at
water courses

Years	Surface water (canals)	Groundwater		Total
		Public tubewells	Private tubewells(1)	
1965-66	58	2.7	4.1	64.8
1969-70	55.5	10.2	11.3	77.0
1974-75	63(2)	22	13.3	98.3
1984-85	77(2)	36	4	117

(1) Based on estimates of private tubewells by Planning Commission.
(2) Excluding water supplies from canal enlargement schemes.

*Kahnert and others, 113. Reference noted under Table 5.16.

6. AGRICULTURAL DEVELOPMENT AND PRODUCTION

Table 6.1[*]

AREA PLANTED WITH HIGH-YIELDING
MEXICAN WHEATS (ACRES)

Crop Year	Country				
	Afghanistan	India	Nepal	West Pakistan	Turkey
1966		7,400	3,500	12,000	
1967	4,500	1,278,000	16,200	255,000	
1968	65,000	6,681.000	61,300	1,800,000	420,000
1969	300,000	10,000,000	133,000	6,000,000	1,430,000
1970 (est.)	360,000	15,100,000	186,000	7,000,000	1,550,000

Source: Dana Dalrymple, Imports and Plantings of High-Yielding Varieties of Wheat and Rice in the Less Developed Nations, Washington, D.C.: International Agricultural Development Service, U.S. Department of Agriculture, 1969, 2 (mimeographed), and United States Department of Agriculture.

[*] Lester R. Brown, "The Social Impact of the Green Revolution," International Conciliation, (January 1971), No. 581, New York: The Carnegie Endowment for International Peace; with comments by L. K. Jha, Sterling Wortman, and Stanley Please, 6.

Table 6.2*

WHEAT AND RICE PRODUCTION TRENDS
IN SELECTED COUNTRIES
(in thousands of metric tons)

YEAR	WHEAT		RICE		
	India	Pakistan	Ceylon	West Pakistan	Philippines
1960	10,322	3,938	611	1,006	2,408
1961	10,977	3,847	613	1,100	2,542
1962	12,072	4,129	682	1,069	2,579
1963	10,829	4,215	698	1,163	2,498
1964	9,853	4,197	716	1,318	2,595
1965	12,290	4,626	515	1,385	2,647
1966	10,424	3,786	649	1,332	2,707
1967	11,393	4,394	780	1,487	2,964
1968	16,568	6,477	916	2,048	2,979
1969	18,700	6,711	935	2,397	3,335
1970 (est.)	21,000	7,329	979	2,628	na

Source: Economic Research Department, U.S. Department of Agriculture.

*Brown, 9. Reference noted under Table 6.1.

Table 6.3*

WHEAT PRODUCTION AND TARGETS IN WEST PAKISTAN,
1964-65 TO 1969-70

Thousand tons

Crop Years	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Production(2)	4,518	3,854	4,266	6,317	6,700	..
Self Sufficiency Targets	-	-	-	5,400	6,100(1)	7,000
OECD Estimates(3)	-	-	-	5,379	6,016	6,713

(1) 6,300 thousand tons given in the Annual Plan 1968-69.

(2) 1964-65 to 1967-68 actuals; preliminary estimate for 1968-69.

(3) OECD Development Centre projections

Sources: See Table 8 in the Appendix for past production. Development Centre projections are explained in the relevant tables in the Appendix.

*Kahnert and others, 95. Reference noted under Table 5.16.

Table 6.4*

WEST PAKISTAN: RICE PRODUCTION AND TARGETS,
1964-65 TO 1969-70

Thousand long tons

Crop Years	1964-65	1965-66	1966-67	1967-68	1968-69	1969-70
Production (1)	1,329	1,296	1,343	1,475	2,070	..
Self-Sufficiency Targets	-	-	-	1,400	1,700 (2)	2,000
OECD Estimates (3)	-	-	-	1,436	1,689	1,837

(1) 1964-65 to 1967-68 actuals, 1968-69 preliminary estimates.

(2) 2,100 thousand tons as given in the Annual 1968-69 Plan.

(3) OECD Development Centre projections which were made before the 1968-69 preliminary estimate was available and are based on normal weather. The difference between the projections and the actual outcome in 1968-69 is probably largely explained by the good weather during that crop season.

Source: See Table 8 in the Appendix for past production. Development Centre estimates are explained in the relevant tables in the Appendix.

*Kahnert and others, 100. Reference noted under Table 5.16.

Table 6.5*

OECD DEVELOPMENT CENTRE ESTIMATE OF WEST PAKISTAN FERTILISER CONSUMPTION

Thousand tons of nutrient

Nutrient / Years	1967-68 actuals	1968-69	1969-70	1974-75
N	177.7	235	300	550
P	11.3	40	65	190
K	0.2	0.5	2	40
Total	189.2	275.5	367	780

Source: Table 21 in Appendix

*Kahnert and others, 120. Reference noted under Table 5.16.

Table 6.6*

WEST PAKISTAN: YIELD PER ACRE OF MAJOR CROPS

Maunds per acre

Commodities	1954/55	1955/56	1956/57	1957/58	1958/59	1959/60	1960/61
Principal Food Crops							
Rice	9.4	9.4	9.4	8.8	9.3	9.0	9.5
Wheat	8.1	8.0	8.4	8.4	8.8	8.7	8.9
Bajra	4.3	4.2	4.3	4.0	4.2	4.4	4.4
Jowar	5.3	5.1	5.1	5.2	5.3	5.5	5.0
Maize	10.9	11.5	11.8	11.2	11.6	10.9	9.9
Barley	6.4	7.6	6.9	8.8	8.8	6.4	7.0
Gram	5.3	5.8	5.0	5.9	5.1	5.8	6.0
Principal non Food Crops							
Sugarcane	317	310	304	308	317	290	325
Rapeseed and mustard	4.6	4.1	4.4	4.6	4.9	4.4	4.7
Cotton (lint)	2.4	2.3	2.3	2.3	2.3	2.3	2.5
Tobacco	18.5	16.8	17.4	17.1	17.5	17.6	16.8
Sesamum	2.8	2.7	2.7	2.6	2.8	2.8	2.4

continued on next page

*Kahnert and others, 362. Reference noted under Table 5.16.

Table 6.6 (continued)

Maunds per acre

Commodities	1961/62	1962/63	1963/64	1964/65	1965/66	1966/67	1967/68
Principal Food Crops							
Rice	10.1	10.0	10.1	10.8	10.2	10.5	11.3
Wheat	8.8	9.0	9.0	9.4	8.2	8.8	11.6
Bajra	4.8	5.4	5.3	5.3	4.8	4.8	4.9
Jowar	5.2	5.6	5.5	5.4	5.0	5.4	5.3
Maize	11.1	11.5	11.4	11.8	10.8	11.5	14.0
Barley	6.7	6.8	6.8	6.9	5.8	5.9	6.7
Gram	5.7	6.0	5.9	6.0	5.5	5.5	4.6
Principal non Food Crops							
Sugarcane	350	377	366	402	405	367	398
Rapeseed and mustard	4.9	5.6	4.8	4.8	4.5	4.8	5.4
Cotton (lint)	2.5	2.9	3.1	2.8	2.9	3.1	3.2
Tobacco	16.7	16.6	18.5	18.3	20.4	20.2	[illegible]
Sesamum	2.8	2.9	3.3	3.0	2.7	2.5	3.1

Sources: 1954/55 to 1960/61 - Handbook of Agricultural Statistics, June 1964, Government of Pakistan, Planning Commission.
1961/62 to 1967/68 - Data received from the Planning Commission, Government of Pakistan, November 1968.

Table 6.7*

WEST PAKISTAN: LAND UTILISATION AND IRRIGATION 1960-61 TO 1965-66

Thousand acres

Area	1960-61	1961-62	1962-63	1963-64	1964-65	1965-66(1)
1. Total area	198,642	198,642	198,642	198,642	198,600	198,598
2. not reported	97,929	96,697	97,174	95,720	67,978	67,974
3. forests	3,052	3,179	3,351	3,598	4,876	4,941
4. not available for cultivation	32,483	32,896	31,064	31,430	47,017	46,753
5. cultivable wastes	24,227	24,157	24,606	25,135	32,408	31,542
6. current fallow	8,841	8,686	8,692	10,249	11,319	12,635
7. Sub-total (2 to 6)	166,532	165,615	164,887	166,142	163,598	163,845
8. Net sown area (1 - 7)	32,110	33,027	33,755	32,500	35,002	34,753
9. irrigated	24,010	25,876	26,444	26,329	27,600	27,374
10. non irrigated	8,100	7,151	7,311	6,171	7,402	7,379
11. Multiple cropped area	2,421	3,447	3,187	4,191	5,140	3,907
12. Total sown area (8 + 11)	34,531	36,474	36,942	36,691	40,142	38,660
13. Intensity of land use in percentage(2)	64.5	65.0	65.0	64.8	61.2	62.4
14. Intensity of cropping in percentage(3)	107.5	110.4	109.4	112.9	114.7	112.9

(1) Provisional estimates.
(2) See note to Table 55 in Appendix.
(3) Percentage of total sown area out of net sown area.

Source: Department of Agriculture, Government of Pakistan, Central Statistical Office and for line (9) the Irrigation Department.

*Kahnert and others, 366. Reference noted under Table 5.16.

Table 6.8*

PROJECTIONS OF FERTILIZER CONSUMPTION BY IACA AND STUDY GROUP

('000 tons of nutrient)

	1964/65	1964/65–1970	1970	1970–1975	1975	1975–1985	1985
IACA:							
(a) Nitrogen	90		120		217		573
(b) Phosphate	-		55		103		335
Total	90		175		320		908
Rate of Increase (% p.a.)		14%		13%		11%	
Study Group:							
(a) Nitrogen	90		250		470		620
(b) Phosphate	-		100		230		330
Total	90		350		700		950
Rate of Increase (% p.a.)		30%		15%		5%	

*Lieftinck and others, 75. Reference noted under Table 4.33.

Table 6.9*

ESTIMATE OF EMPLOYMENT IN AGRICULTURE, 1965-85

	1965	1975	1985
Crops			
Cropped Acres (millions)	40.72	47.84	54.30
GPV of Crops per Acre (Rs)	133	184	260
Employment (mln. man-years)	4.7	5.8	6.9
Livestock			
Gross Production Value (Rs min.)	3.3	5.6	9.8
Employment (mln. man-years)	1.9	2.7	3.9
Total Agricultural Employment	6.6	8.5	10.8
Total Labor Force	16.2	21.2	28.1
Agriculture as % of Total	40.7%	40.1%	38.4%

*Lieftinck and others, 211. Reference noted under Table 4.33.

Table 6.10*

GROWTH OF WEST PAKISTAN AGRICULTURAL SECTOR AND CONTRIBUTION TO GROSS PROVINCIAL PRODUCTION 1949-50 TO 1964-65

(Rs. million at constant 1959-60 prices)

	1949-50	1954-55	Average Rate of Growth 1950-55	1959-60	Average Rate of Growth 1955-60	1964-65[a]	Average Rate of Growth 1960-65
Crops	4,250	4,320	0.3	4,775	2.0	6,018	4.7
Others	2,345	2,628	2.3	2,936	2.2	3,258	2.1
Total Agriculture	6,595	6,948	1.0	7,711	2.1	9,276	3.8
Agriculture's Percentage of GPP	54.5	48.8		46.3		42.4	

[a]These official estimates of recent production differ from IACA's estimates of GPV and value added because IACA has used its own assumptions for farm costs, farm prices, livestock production, acreage cropped and volume of production. The Study Group worked mainly from IACA estimates.
Source: Central Statistical Office.

*Lieftinck and others, 5. Reference noted under Table 4.1.

Table 6.11*

CROPPED ACREAGE AND GPV FOR CANAL-IRRIGATED AND OTHER AREAS (1965)

(millions)

	Canal-Irrigated		Remainder		West Pakistan	
	Area in Acres	GPV Rs	Area in Acres	GPV Rs	Area in Acres	GPV Rs
Annual Food Crops						
Wheat	7.72	1,222.5	4.99	412.5	12.71	1,635.0
Millets	1.02	68.2	1.99	136.8	3.01	205.0
Maize	1.09	128.6	1.07	122.4	2.16	251.0
Others	3.08	412.9	3.12	288.1	6.20	701.0
Rice	3.52	589.0	-	-	3.52	589.0
Perennial Crops	1.62	1,112.0	-	-	1.62	1,112.0
Total Food Crops	18.05	3,533.2	11.17	959.8	29.22	4,493.0
Cotton	3.71	880.0	-	-	3.71	880.0
Fodder	4.99	-	1.20	-	6.19	-
Total Crops	26.75	4,413.2	12.37	959.8	39.12	5,373.0

*Lieftinck and others, 72. Reference noted under Table 4.33.

Table 6.12*

LAND OWNERSHIP PATTERN

	Up to 5 acres	5-25 acres	25-100 acres	More than 100 acres	Total
Number of owners (thousands)	3,266	1,452	286	63	5,067
Percent of owners	64	29	6	1	100
Area owned (thousand acres)	7,427	15,438	10,616	15,616	48,641
Percent of area owned	15	32	22	31	100

Source: IACA's Comprehensive Report, Volume 8, page 8.

*Lieftinck and others, 31. Reference noted under Table 4.1.

Table 6.13*

ECONOMIC STRUCTURE OF WEST PAKISTAN, 1950-65

(percent of GPP at factor cost)

	1949/50	1959/60	1964/65
Agriculture	54.3	46.3	41.8
Manufacturing and Mining	8.5	13.6	17.6
Construction	1.5	2.6	4.1
Transport and Communication	5.0	5.5	5.3
Government	5.0	4.7	4.4
Other Services	25.7	27.3	26.8

*Lieftinck, Pieter, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources of West Pakistan, A Study in Sector Planning, (Baltimore, Maryland: The Johns Hopkins Press for the World Bank, 1969), Volume III, 18.

Table 6.14*

IACA'S POPULATION ESTIMATES

Region	1965 Millions	1965 Percent	1985 Millions	1985 Percent
Peshawar	14	27	22	25
Punjab	26	50	43	50
Sind and Karachi	10	20	19	22
Rest of Province	1	3	3	3
Total West Pakistan	51	100	87	100
Rural	38	74	50	57
Urban	13	26	37	43

Source: IACA's Comprehensive Report, Volume 1, page 5.

*Lieftinck and others, 29. Reference noted under Table 4.1.

PART III: INSTITUTIONS FOR RESEARCH AND INFORMATION

7. Pakistan

7. Research and Information Institutions in Pakistan

This section rests heavily upon the following:

Akhtar H. Siddiqui, "Pakistan in the World of Research and Learning; A Guide to Research and Development Organisations," Karachi: Pakistan Reference Publications, 1968.

Included in this section is an exhaustive listing of research institutions in Pakistan, whether or not they are primarily concerned with water resource planning, development, and administration.

Agricultural Development Bank of Pakistan
Habib Square, Bunder Road, Karachi

Established:	1961
Status:	Semi-government
Functions:	Provides credit facilities to agriculturists (including those in fisheries, forestry, animal husbandry, poultry, farming, etc.); Besides, individual public and private limited companies engaged in agricultural activities are eligible for loans; Short term loans are offered for such requirements as seed, fertilizers, plant protection measures; Medium term loans for implements, purchase of animals, digging of wells, and long term loans for major improvement like installation of tube wells, purchase of tractors.
Library:	Approximately 3,000 volumes
Publications:	Evaluation and progress report (monthly), Annual Reports and Miscellaneous publications.

Agricultural Development Corporation
Lahore

Established:	1961 and abolished in 1971
Status:	Semi-government
Functions: Agronomy Section	Colonisation of new land in G.M. Barrage, Guddu Barrage, Taunsa Project, Thal and Soan Valley; Trial of improved varieties and plant use; Flow and sprinkler irrigation.
Publications:	Annual reports.

Agricultural Research Council (formerly Food & Agriculture Council)
Block-79, Pakistan Secretariat, Karachi

Established:	1949
Status:	Central Government
Functions:	Organisation, co-ordination and promotion of scientific research in various fields of agriculture; Arrangement for the utilization of the results of the researches carried out by the institutes and laboratories, associated with the Council; Establishment on a national basis of research institutes and other organisations for undertaking special studies and research in agriculture; Dissemination of scientific and general information relating to research work of the Council; Establishment of liaison with other national and international organisations engaged in agricultural research; Making of grants and awards of fellowships and scholarships for training.
Publications:	Agriculture Pakistan (Quarterly), Agricultural Research in Pakistan, 1965, Miscellaneous publications.

Agricultural Research Institute
Tandojam (Hyderabad)

Established:	1928
Status:	Provincial Government
Functions:	Research work on nutritional requirements of crops; Work on soil chemistry and soil testing, soil physics, soil microbiology and agricultural chemistry.
Publications:	Research reports and papers.

Agricultural Research Institute
Tarnab Farms, Peshawar

Established:	1912
Status:	Provincial Government
Functions:	Fundamental and applied research in botany, plant pathology, entomology, economic botany, agricultural chemistry and food technology, farm management.
Library:	Approximately 5,000 volumes.

Agricultural Research Institute
Tejgaon

Established:	1905
Status:	Provincial Government

Agricultural Research Institute-Tejgaon (continued)

Functions:	Fundamental and applied research in mycology and plant pathology; entomology; economic botany, agriculture chemistry.
Library:	Approximately 5,000 volumes.
Publications:	Agricultural Bulletin
Research Stations:	Barisal: Agric. Research Sub-Station Bogra: Agric. Research Sub-Station Chittagong: Agric. Research Sub-Station Dinagpur: Agric. Research Sub-Station Habiganj: Deep Water Paddy Research Station Isurdi: Seed Testing Laboratory Jamalpur: Agric. Research Sub-Station Mymensing: Agric. Research Sub-Station Pabna: Agric. Research Sub-Station
Research Sub-Stations:	Burishat (Rangpur); Jessore; Rahmatnagar (Barisal); Rajshahi.

Atomic Energy Agricultural Research Centre
Tandojam (Hyderabad)

Established:	1963
Status:	Semi-government
Functions:	Research studies in various fields of agriculture with the application of radiation and radio-isotopes.
Library:	Approximately 3,500 volumes.
Publications:	Research reports.

Atomic Energy Centre
Ferozpur Road, Lahore

Established:	1961
Status:	Semi-government
Functions:	Research work in Nuclear physics, radiobiology, radiation chemistry, radiochemistry, electronics.
Library:	11,000 books and reports
Publications:	Research reports; Library bulletins; Miscellaneous publications.

Boards of Economic Enquiry

Locations: Peshawar
Lahore
Hyderabad

Board of Economic Enquiry, Peshawar
P. O. Peshawar University, Peshawar

Established:	1953
Status:	Semi-government
Functions:	To conduct economic and social studies in the NEFP and tribal areas adjoining West Pakistan and to give a practical bias to the teaching of economics in the University of Peshawar.
Library:	Over 1,700 volumes.
Publications:	Numbered monographic series; Special reports, surveys, case studies, etc.

Bureau of Statistics
Dept. of Planning and Development, Government of West Pakistan, Lahore

Established:	1960 -- Function now being redistributed between the four new provinces.
Status:	Provincial Government
Functions:	Collection, compilation and publication of statistical data on all aspects of economic and social life of West Pakistan.
Publications:	Statistical year books, other statistical publications.

Central Control Laboratory
413 Jinnah Colony, Lyallpur

Established:	1947
Status:	Central Government
Functions:	Carrying out of analytical work and specification of agricultural products; Training of chemists in food and analytical work.
Library:	1,000 volumes.

Central Fisheries Department
West Wharhf, Karachi

Established: 1948
Status: Central Government
Functions: Biological and technological research including studies on fish drying and curing methods; Testing of fish gear and fishing methods in deep sea and inshore exploration; Processing of fish products like manure and meal.

Central Statistical Office
Government of Pakistan, 1 - SMCM Society, Karachi

Established: 1949
Status: Central Government
Functions: To collect, compile and collate and publish statistical data of national importance on all aspects of economic life.
Publications: Census of manufacturing industries, CSO News Letter (monthly), Foreign Trade Statistics, Prices Bulletins, Sample Surveys, Socio-economic indicators, Statistical Bulletins on Prices, Statistical Bulletin (monthly).

Central Testing and Standards Laboratories
Government of Pakistan, Block 77, Pakistan Secretariat, Karachi

Established: 1951
Status: Central Government
Functions: Scientific assessment of industrial raw materials, finished products and exportable commodities; Scientific guidance to government purchase and inspection departments, indigenous industries and commercial enterprises.
Library: 4,000 volumes.

Cooperative Institute of Management
13/14 Gulberg, Lahore

Established: 1963
Status: Semi-government
Functions: Consultation and advice to cooperative organisations on all problems of business management; Research studies into management problems faced by cooperative enterprise; Publication of manuals, booklets, periodicals, course scripts, forms, accounting records and other instruments of management for use by cooperative organisations and training in management concepts and techniques.

Department of Administrative Science, Bureau of Research in Administration and Development, University of the Punjab
Lahore, New Campus

Established:	1962
Status:	Provincial Government
Function:	Conducts research on public policy, planning and administration problems.
Publications:	Issues periodic monographs and special studies.
Library:	Over 15,000 volumes.

Department of Locust Warning and Plant Quarantine
Karachi

Established:	1948
Status:	Central Government
Functions:	Research studies on the behaviour, biology, phase variation, natural enemies and diseases of the desert locust in the field as well as in the laboratory; Application of radioisotopes and radiation in the control of agricultural insect pests; Studies on the use of Gamma radiation; Studies on plant diseases.
Library:	5,000 volumes.

Department of Marketing Intelligence and Statistics
Government of Pakistan, Karachi

Established:	1947
Status:	Central Government
Functions:	Research and economic studies in agricultural marketing and farm management; Grading and marking of woll, goat hair, sannhemp and coriander seed; Collection, compilation and publication of prices of various agricultural products at different markets of the country.
Library:	7,000 volumes.
Publications:	Markets and Prices, Reports on Marketing of Agricultural Products, Weather and Crop Reports.

Directorate of Family Planning and Health Education
Ministry of Health, Labour, and Social Welfare, Government of Pakistan, Karachi

Established:	1948
Status:	Provincial Government
Functions:	Research on bionomics and culture of prawns and fisheries.
Publications:	Annual reports

Directorate of Land Reclamation
Lahore

Established:	1948
Status:	Provincial Government
Functions:	Investigation into the cases and remedial measures for amelioration of water-logged, saline and alkaline lands of the Province of West Pakistan.

Directorate of Livestock Farms
Lahore

Established:	1947
Status:	Provincial Government
Functions:	Administrative control and co-ordination of the research work carried out by the various livestock experiment and research stations in West Pakistan.

Directorate of Nutrition and Research
Ministry of Health, Labour and Social Welfare, Government of Pakistan, Islamabad

Established:	1960
Status:	Central Government
Functions:	Triphasic (biochemical, chemical, dietary) nutrition survey of the Pakistan population to appraise levels of food consumption vis-a-vis prevalent nutritional status and health conditions of Pakistani rural and urban population; Conducts research on problems projected therein.
Library:	1,000 volumes.

Direcorate of Social Welfare
Lahore

Established:	1956
Status:	Provincial Government
Functions:	Deals with welfare activities training, research, urban community development, medical social work, child and youth welfare, recreational services for children and youth, delinquency and probation; Rehabilitation and training of the socially and physically handicapped and financial assistance to voluntary welfare agencies.
Publications:	Miscellaneous publications on social welfare.

Directorate of Veterinary Research
Lahore

Established: 1947
Status: Provincial Government
Functions: Administrative control and co-ordination of the research work carried out by the animal husbandry and veterinary research institutes in West Pakistan.

Economic Affairs Division
President Secretariat, Rawalpindi

Established: 1948
Status: Central Government
Functions: Deals with assessment of economic requirements and negotiations for securing economic and technological assistance from foreign governments and organisations; Maintains liaison with ECOSOC, ECAFE, CENTO, SEATO, and Commonwealth in connection with economic matters; Collects, compiles and publishes statistical data concerning trade, prices, industry, national income, etc.
Publications: Economic Survey of Pakistan, Basic Facts of Pakistan, Other publications.

Economic Research Academy
506 Qamar House, Bunder Road, Karachi

Established: 1962
Status: Private
Functions: Promotion of research and to make available research facilities to private agencies.

Geological Survey of Pakistan
Quetta

Established: 1947
Status: Central Government
Functions: Geological and topological mapping and surveys; Mineral investigations; Ground water investigations; Study of the engineering geological problems.
Library: 10,000 volumes.
Publications: Geological surveys of Pakistan, Annual reports.

Government Fruit Research Station
Mirpur Khas

Established:	1907
Status:	Provincial Government
Functions:	Acclimatization, selection and production of plants of various types of fruit crops; Improvement in fruit quality, production of fruits and vegetables and research on the technology of fruit and vegetable processing.

Industrial Development Bank of Pakistan
Kandawalla Building, M.A. Jinnah Road, Karachi

Established:	1961
Status:	Semi-government
Functions:	A successor to the Industrial Finance Corporation of 1949. It is in addition being a normal commercial bank, a specialised institution dealing with long term credit to small and medium size industries, normally upon a maximum of Rs. 2.5 million including a foreign exchange component not exceeding Rs. 1.5 million; Provides loans both in local and foreign currency with a view to accelerating the tempo of industrial development. It has an authorised capital of Rs. 30 million which is fully subscribed, the majority being held by Government.
Library:	1,500 volumes.
Publications:	Annual reports, Miscellaneous publications.

Institute of Business Administration
University of Karachi, Karachi

Established:	1956
Status:	University Institute
Functions:	Training and education in business administration leading to Degree Cources; Research studies on various aspects of business administration and management.
Library:	20,000 volumes.
Publications:	Research studies, survey reports.

Institute of Meteorology and Geophysics
Government of Pakistan, Quetta

Established:	1961
Status:	Central Government

Institute of Meteorology and Geophysics (continued)

Functions:	Research work on long range and medium range forecasting techniques; Offers training facilities in all branches of meteorology and allied sciences.
Publications:	Monthly bulletins containing character figure, hourly K-indicates and special magnetic phenomena.

Investment Advisory Centre of Pakistan
4th Flood Farid Chambers, Victoria Road, Karachi

Established:	1963
Status:	Semi-government
Functions:	Provides Pakistani and foreign enterpreneurs with preinvestment counselling and preparation of feasibility reports; Assists the PICIC and the IDBP in the evaluation and appraisal of investment proposals; Provides assistance to the Department of Investment Promotion and Supplies and other Government departments and agencies; Prepares preinvestment studies and portfolio-briefs of projects for those areas and sectors which are covered by the five year plans and reserved for private investment.
Library:	2,000 volumes.
Publications:	Reports, surveys, etc.

Investment Corporation of Pakistan
5th Floor, National Bank of Pakistan Building, Karachi

Established:	1966
Status:	Semi-government
Functions:	Responsible for broadening the base of investments and developing the capital market in Pakistan; Underwrites shares and debunture issues and to provide a mechanism by which the equities of public limited companies will be effectively distributed to as wide a group of savers as possible.
Library:	1,000 volumes.

Investment Promotion Bureau
Karachi

Established:	1959
Status:	Central Government
Functions:	To promote domestic and foreign industry; To meet the planned targets for private sector; To speed up through official channels applications for establishment of new industries; To offer advice and guidance

Investment Promotion Bureau (continued)

to ministries and to help foreign and home investors; To obtain import licences, building materials, land, power, and other materials for which approval of central or provincial governments is required.

Irrigation Research Institute
Lahore

Established: 1922
Status: Provincial Government
Functions: Basic research on irrigation; Design of canals; Hydraulic works; Measures to combat waterlogging and the determination of soils and alkalis; Specific research on designs of weirs, canals, dams, reservoirs, flood control, ground water studies, analysis of guage and discharge data of weirs.
Library: Over 10,000 volumes.
Publications: Annual reports, Memoirs, Technical reports, Special papers.

Medical-Social Research Project (Population)
G.P.O. Box 349, Lahore

Established: 1961
Status: Central Government
Functions: Undertakes the investigation of factors which influence health of mothers and children with particular attention to family planning.

National Council of Social Welfare
56, Pakistan Secretariat, Shahrah-i-Iraq, Karachi

Established: 1956
Status: Central Government
Functions: To assess the needs and activities of voluntary organisations and provides them with necessary stimulus, guidance, financial and technical assistance.

National Economic Council
Government of Pakistan, Rawalpindi

Status: Central Government. It is the supreme decision making body in the economic sphere, headed by the President of Pakistan.

National Economic Council (continued)

Functions:	Review of the over all economic position of the country; Formulation of plans with respect of financial, commercial and economic policies and the economic development of the country; Approval of the five-year plans, the annual development programmes, the central and public sectors, and all nonplan schemes; Steps for removal of economic and per capita income disparity between provinces and between areas within a province.

National Institutes of Public Administration, located at Lahore and Karachi

Lahore: 78, Upper Mall

Established:	1962
Status:	Semi-government under provincial governing board
Functions:	Training in administration for officers with managerial responsibilities; Conducts research in government administration; Offers consulting services and in-service training; Improvement of measures and aims at promoting a professional approach to public administration in Pakistan.
Library:	Over 10,000 volumes.
Publications:	NIPA/News and Views, Public Administration Review Research reports, Miscellaneous publications.

Karachi: University Road

Established:	1962
Status:	Semi-government under central government governing board.
Functions:	See above.
Library:	Over 6,000 volumes.
Publications:	NIPA Journal, Research reports, Miscellaneous publications.

National Manpower Council
324 Taghlaq House, Karachi

Established:	1962
Status:	Central Government. Headed by the Minister of Health, Labour and Social Welfare, and includes members of the Planning Division, from all important ministries, from two provinces and from Railway Boards.
Functions:	To evolve policies and programmes for the development and utilization of human resources; To devise means

National Manpower Council (continued)

for meeting requirements of trained personnel on the one hand and of productive employment for the surplus labour and youth on the other; To draw up schemes for improved utilization of labour through better management; To establish a manpower planning organisation for development of basic data and analysis for manpower planning.

National Research Institute of Family Planning
41-B Block VI, T.E.C.H. Society, Karachi

Established:	1962
Status:	Central Government
Functions:	In collaboration with the Jinnah Post Graduate Medical Centre carries out studies in basic and functional research on different aspects of family planning; Besides clinical investigation it also undertakes sociological and demographic research.
Library:	1,500 volumes
Publications:	Pakistan Journal of Family Planning, Progress Reports

National Science Council
Al-Rafiq, 48 Darul Aman, Drigh Road, Karachi

Status:	Semi-government
Functions:	Co-ordination of the plans, programmes and schemes of scientific research prepared by various research councils; Assessment and evaluation of the results of research conducted by the research councils; Advise to the Central Government on matters connected with the development of scientific research, including any particular issue referred to it by Government.
Library:	2,500 volumes
Publications:	Science News, Register of current research in Pakistan.

Oil and Gas Development Corporation
Karachi

Status:	Semi-government
Functions:	Deals with the extraction and development of oil and gas.
Publications:	Annual reports.

Pakistan Academy for Rural Development
Peshawar

Established:	1959
Status:	Semi-Government
Functions:	Undertakes research and provides advanced training courses for the officers of the national building departments in the problems and methods of rural development and to conduct research in order to gain an insight into the factors involved; Runs several pilot projects relating to co-operation in agriculture, rural education, irrigation, and family planning.
Library:	Over 8,000 volumes.
Publications:	Message, Research surveys and reports.

Pakistan Academy of Sciences
Islamabad

Established:	1954
Status:	Private
Functions:	Promotion of scientific research; Publications of scientific journals; Establishement of scientific libraries, laboratories and institutions; Awards and grants of fellowships, scholarships, prizes and medals for scientific research.
Publications:	Proceedings of Science Conferences.

Pakistan Administrative Staff College
The Mall, Lahore

Established:	1960
Status:	Semi-government
Functions:	Research in all aspects of administration in Pakistan and its comparisons with parallel experiences in other developing countries; Preparation of teaching materials.
Library:	15,000 volumes.
Publications:	Pakistan Administrative Staff College Quarterly; Miscellaneous publications on Public Administration.

Pakistan Association for the Advancement of Science
Ismail Aiwan-e-Science, Ferozpur Road, Lahore

Established:	1948
Status:	Private
Functions:	Promotion and cultivation of science in all its branches including its application to practical problems and to encourage research in all branches of

Pakistan Association for the Advancement of Science (continued)

science; Publication of proceedings, journals and books; Organisation of national and international scientific conferences.

Library: 5,000 volumes.

Publications: Pakistan Journal of Science, Pakistan Journal of Scientific Research, Proceedings of the Scientific Conferences, Miscellaneous Publications

Pakistan Atomic Energy Commission
30/A-6, P.E.C.H. Society, Main Drigh Road, Karachi

Established: 1956

Status: Semi-government

Functions: Planning and development of peaceful uses of atomic energy with special reference to survey, procurement and disposal of radioactive minerals; Planning and establishment of atomic energy and nuclear research institute; Installation of research reactor and power reactors; Application of radioisotopes to agriculture, health and industry.

Publications: Nucleus, Miscellaneous publications, Library bulletins, Research reports.

Pakistan Council of Scientific and Industrial Research
Karachi

Established: 1953

Status: Semi-government

Functions: Initiation, promotion and guidance of scientific and industrial research having or bearing on problems connected with the establishment and development of industries or with any other allied matter referred to the Council by the Central Government; Establishment and development of national institutions for research with the object of utilizing the economic resources of the country in the best possible manner; Undertakes and fosters development research for the utilization of discoveries and inventions resulting from researches of the Council; Collection, compilation and dissemination of information on scientific and industrial matters.

Library: 10,000 volumes

Publications: Karwar-i-Science, Pakistan Journal of Scientific and Industrial Research, Science and Industry Science Chronicle, Scientific Researches, Annual reports.

Pakistan Economic Research Institute
9 Jan Mohammad Road, Lahore

Established:	1956
Status:	Private
Functions:	To undertake socio-economic investigation and to co-ordinate research in economic problems of Pakistan; To collect, compile and interpret statistical data; To publish the results and findings of various investigations.
Publications:	Miscellaneous publications on economics.

Pakistan Forest Research Institute
P.O. Peshawar University, Peshawar

Established:	1947
Status:	Central Government
Functions:	Research work on sericulture, forest botany, forest entomology, soil chemistry, wood utilization and survey of medicinal plants; Training in forestry.
Library:	10,500 volumes
Publications:	Pakistan Journal of Forestry, Miscellaneous publications.

Pakistan Industrial Credit and Investment Corporation
Jubilee Insurance House, McDeod Road, Karachi

Established:	1958
Status:	Semi-government
Functions:	Along with the IDB it acts as the channel by which foreign exchange loans negotiated by the government reach the private sector; Provides medium term loans in foreign and local currencies in addition to equity participation; It shares the financing of large projects; Also underwrites shares to assist in the development of the capital market; It gets credit in foreign currency from IBRD, AID, West Germany, France, Japan, Poland, Italy, Yugoslavia.

Pakistan Institute of Cotton Research and Technology
New Queens Road, Karachi

Established:	1952
Status:	Semi-government
Functions:	Research work on processing, textiles bleaching, textiles physics, cotton seed chemistry and textile chemistry.

Pakistan Institute of Cotton Research and Technology (continued)

Library:	6,000 volumes.
Publications:	Cotton Review, Pakistan Cotton, Miscellaneous publication on cotton and cotton textile.

Pakistan Institute of Development Economics
Old Sind Assembly Building, Bunder Road, Karachi; In 1971 moved headquarters to Dacca, East Pakistan.

Established:	1960
Status:	Semi-government
Functions:	The Institute carries out basic research studies on the economic problems of development in Pakistan and other Asian countries; Provides training in economic analysis and research methodology for the professional members of its staff and for members of other organizations concerned with development problems.
Library:	30,000 volumes.
Publications:	Annual reports, Banking Statistics, Export receipts, Foreign liabilities and foreign investment in Pakistan, Pakistan's balance of payments, State Bank News, State Bank of Pakistan Bulletin, Statistics on scheduled banks in Pakistan.

Pakistan Institute of International Affairs
Havelock Road, Karachi

Established:	1947
Status:	Private
Functions:	To encourage and facilitate the understanding of international affairs and of the circumstances, conditions, and attitudes of foreign countries and their peoples and to promote the scientific study of international politics, economics and jurisprudence.
Library:	15,000 volumes.
Publications:	Pakistan Horizon, Miscellaneous publications.

Pakistan Standards Institution
39 Garden Road, Karachi

Established:	1948
Status:	Semi-government
Functions:	Promotion of trade, commerce and industries on scientific lines; Popularisation of voluntary adoption of standards; Serves as clearance house for information on standardisation.

Pakistan Standards Institution (continued)

Library:	5,000 books and a large number of standards specification from various countries.
Publications:	Standards Bulletin.

Planning and Development Department
Government of West Pakistan, Lahore

Status:	Provincial Government
Functions:	To scrutinise and approve from the technical point of view all development projects in the public sector above a prescribed limit, which are to be included in the National Five-Year Plans or in the annual development programmes; provincial plans; To implement the plans.
Publications:	Miscellaneous publications on development planning and projects.

Planning Division
President's Secretariat, Rawalpindi

Status:	Central Government
Functions:	Assessment of the material and human resources of the country; Analysis of and recommendation on important economic policies and programmes; Formation of national plans and programmes; Making overall evaluation of the progress achieved; Maintenance of data for the purpose of foreign aid negotiations; Reporting on the progress of projects.
Publications:	Five-Year Plans, Bibliographical works, Other publications.

Punjab Agricultural Research Institute
Risalewala, Lyallpur

Established:	1962
Status:	Provincial Government
Functions:	Evaluation of better varieties of crops; Research work on field crops with special reference to cultural requirements for field operation; Water requirement; Control of insects, pests and diseases; Research studies on cereals; Food technology, etc.
Library:	Over 4,500 volumes.
Publications:	Results of research studies.

Punjab Board of Economic Inquiry
3 Faridkot Road, Lahore

Established:	1946 (Earlier Board established in 1920 under British-Indian Government)
Status:	Semi-government
Functions:	To carry out economic investigations, particularly in the province of the Punjab; To encourage and direct economic studies and research; To publish the results of all inquiries carried out by the Board.

Social Science Research Centre
University of the Punjab, New Campus, Lahore

Established:	1959
Status:	University Institute
Functions:	Research in applied economics, sociology and demography; Training for social research; Assistance to research workers in the various departments of the Faculty of Social Sciences of the University.
Library:	3,000 volumes.
Publications:	Research studies and surveys

Space and Upper Atmospheric Research Committee
43/15-K, T.E.C.H. Society, Karachi

Established:	1963
Status:	Semi-government
Functions:	Space and upper atmospheric research

State Bank of Pakistan
McLeod Road, Karachi

Established:	1948
Status:	Semi-government
Functions:	Regulation of the issue of bank notes and keeping of reserves with a view to securing monetary stability in Pakistan, and the operation of the currency and credit system of the country; Acts as a banker to the Central and Provincial Governments; Maintains close relationship with commercial banks, every bank has to maintain minimum reserve of 5% with the State Bank; Regulation of credit to meet exigencies of changing situation; Responsible for bank rate changes and open market operation; Provides advisory and supervisory service to scheduled banks; Maintains the external

State Bank of Pakistan (continued)

value of the rupee, and administers foreign exchange regulations; Undertakes research studies in economics and its various aspects.

Universities

Six universities in West Pakistan:

University of the Punjab, Lahore, chartered during British-Indian Government
University of the Sind, Hyderabad, chartered in 1947
University of Peshawar, chartered in 1950
University of Karachi, Karachi, chartered in 1951
West Pakistan Agricultural University, Lyallpur, chartered in 1961
West Pakistan University of Engineering and Technology, chartered in 1961

Veterinary Research Institute
Lahore

Established:	1947
Status:	Provincial Government
Functions:	Preparation of biological products; Studies on the development of improved techniques of production and standardisation of veterinary biologicals.

West Pakistan Animal Husbandry Research Institute
Peshawar

Established:	1949
Status:	Provincial Government
Functions:	Research work on pathology, bacteriology, biological products, parasitology, hides and skins, poultry and animal nutrition, control of diseases, improvement of livestock breeds.
Library:	4,000 volumes.
Publications:	Numbered monographic series

West Pakistan Bureau of Education
Government of West Pakistan, Lahore

Established:	1958
Status:	Provincial Government
Functions:	Collection, compilation, analysis and dissemination and exchange of educational information in the form of documents, bibliographies, educational maps, charts and other audio-visual materials; Assistance to educationists and research scholars, administrators and legislators, parents and those interested in the development of education.

West Pakistan Institute of Management
Shahrah-Iran, Clifton, Karachi-6

Established:	1954
Status:	Semi-government
Functions:	Offers a comprehensive teaching program of management development for people at senior, middle, and junior level responsibilities; Holds seminars and conferences on different areas to management; Offers counselling service to all business and industrial undertakings.
Publications:	Pakistan Management Review.

West Pakistan Engineering Congress
Lahore

Established:	1912
Status:	Private
Functions:	Promotion and the well-being of the congress by affording members an opportunity of meeting annually to discuss subjects of professional or departmental interest.
Publications:	Proceedings of Engineering Congress, Engineering News

West Pakistan Family Planning Board
Lahore

Established:	1962
Status:	Provincial Government
Functions:	Deals with the implementation of the schemes and the administrative functions connected therewith and in particular for the training programme.
Publications:	Progress report on family planning in West Pakistan.

West Pakistan Veterinary Research Institute
Peshawar

Established: 1947
Status: Provincial Government
Functions: Preparation of biological products including African horse sickness, virus vaccine; Studies on the development of improved technique of production and standardisation of veterinary biologicals.

West Pakistan Water and Power Development Authority
The Mall, Lahore

Established: 1958
Status: Semi-government
Functions: It is charged with the responsibility of multi-purpose development of the water and power resources within West Pakistan on a united and co-ordinated basis, including reclamation of water-logged, salinised and flooded areas; Also assigned the task of making the electricity system adequate for the growing industrial and agricultural needs of the Province; In addition, it is entrusted with the task of implementing the Indus Basin Settlement Plan as an Agent of the Government.
Publications: Indus, Miscellaneous publications, reports, etc.; Statistical data relating to water and power development in West Pakistan.

PART IV. GLOSSARY

8. PAKISTANI TERMS AND NAMES

PART IV: 8. PAKISTANI TERMS AND NAMES

8.1 General Pakistani Terms

Abadi	Populace
Abadis	Agricultural settled areas. Aggregation of houses.
Abi/Aabi	Irrigated
Abiana	Water rates
Abzaia	Water run to waste, vide section 34, Canal Act VIII of 1873.
Ambar charkla	An improved hand-operated machine for the spinning of cotton.
Amin	Formerly an official who made the final measurements of the irrigated crop.
Amon paddy	The seasonal rice crop grown in the late summer and fall (local term in E. Pakistan).
Anna	One-sixteenth of a rupee (not in use now).
Ansar	A member of the local home guard, which is a defense unit in the village; not on the regular police or army payroll.
Assessment circle	An assessment circle is a group of villages possessing similar agricultural conditions, i.e., soil, rainfall, depth of water, climate, type of irrigation and type of crops grown, so that they have similar revenue-paying capacity and permit the imposition of a uniform assessment rate. Within an assessment circle all the yield-increasing factors are assumed to be constant.
Assessment Clerk	The official in charge of the Vernacular Revenue accounts work and records of the Divisional Office.
Athbundi	Stone-walled bench terrace.
Atta	Whole wheat flour
Aus paddy	The seasonal rice crop grown in spring and early summer (local term in E. Pakistan).

Bagasse	Sugar cane fibre waste after cane crushing.
Banjan land	Land available for cultivation but not being cultivated.
Banjar	Uncultivated land.
Bania	Hindu shopkeeper and money-lender.
Baqreid	Eid of sacrifice, a famous Islamic festival celebrated following the day of Pilgrimage to Mecca by sacrificing animals in commemoration of the prophet Abraham.
Bar	Tableland between two rivers.
Bara	Soil, the clay complex of which is almost completely saturated with sodium and is impervious to water.
Baradari/Sharika	An important village grouping where the members share a common ancestor.
Barani	Dry land-farming, farming in rain-fed areas.
Barkat	Continuing benefits, or blessings.
Basmati	Group of fine rice varieties.
Batai tenants	Tenants who usually receive 50% of the produce grown on the land.
Bela	Uncultivated land in riverbed.
Bet	Low-lying river in country.
Bhaichara	Brotherly association.
Bhusa (Busa)	Fine-structured wheat straw.
Bigha	One half of an acre of land.
Boro paddy	The seasonal rice crop grown in the winter months. In most places irrigation is necessary for this crop. (Local term in E. Pakistan.)
Bosi	A rabi crop grown solely on a single autumn watering.
Bradri	Group of related families generally living in a community or village.
Brahman	A priestly caste among Hindus at the apex of the caste pyramid.

Bund	Embankment for retaining water. A large artifical embankment which protects agricultural lands from river floods. The term is also applied to small earth ridges separating two fields or sections of fields.
Burqa	A full length all-covering garment for women, with a peep hole for each eye.
Carvan sarai	A kind of inn where caravans used to stay.
Caste	Hereditary classes of social organization, at times has occupational significance.
Chahi	Land irrigated by lift from wells.
Chak or Eaon	Village or maybe an area served by one or more outlets from an irrigation ditch.
Chakbandi	The mapping out of the area irrigated by the outlets of a distributary and the preparation of the list of share-holders thereon.
Chanda	Donations collected for any project of common benefit.
Changars	A low caste, often sweepers, deal with skins and hides, correspond to scheduled castes in India.
Chapati	Unleavened break baked in thin slabs, similar to tortilla.
Charka	A single-thread hand spinning machine (See ambar charka).
Chatta	Method of sowing by broadcasting the seed.
Chiragah	Lands meant for grazing livestock, with no well defined ownership and require little, if any, care to manage them. (This does not include irrigated pastures.) Synonymous to "rangeland" which occupies 75% of the area of West Pakistan.
Circle	The group of villages which form the area measured by one Patwari called in vernacular a "halqa."
Chowkidar	Watchman, security guard.
Crore	One hundred lakhs -- ten million.
Dai	Midwife.
Daftari	Records keeper in government offices

Darul aloom	See Maktab.
Deh	Administrative division in rural areas; a village.
Desi	Indigenous, applies to varieties of plants as well as implements, e.g., desi cotton = unimproved local variety of cotton; desi plough = unimproved local wooden plough.
Dheki	A simple machine by which paddy is husked and partially polished; this is accomplished by a perpendicular peg on the end of a pole dropping into a steep-sided stone or wood container.
Dhors	Old meander depression.
Doab (Doaba)	Tract of land between two rivers (see also Bar).
Dofasli Dosala	Yielding two crops in two years.
Dubari	A rabi crop grown solely on residual soil water from the previous kharif crop.
Durry	Cotton Carpet.
Eid	An important Islamic festival preceded by the holy month of Ramzan/Ramadan, when the Muslims keep fast.
Fakir	In the terminology of "sufism" Muslim ascetic. In common language 'beggar.'
Fard Darkhwast Kharabe	Application for remission of land revenue on account of failed crops.
Fard-I-Raftar	Program of inspection.
Fard Mushtabha	A list of fields the irrigation of which is disputed or open to doubt.
Farz	A religious duty order as prescribed by Quran.
Ghandis	A nomadic tribe which drives its livestock to summer pasturage in the high mountain meadows and winters in the occupied plains areas.
Ghee/Ghi	Clarified butter.
Gujars	A tribal caste name.
Gur	A form of unrefined sugar.

Guzara forest	A village forest or pasture in which trees belong to the State. Forests excluded at the time of reservation to meet the requirements of the local population both for timber and fuel and for grazing.
Hakeem (Hakim)	Physician practicing indigenous medicine.
Halqa	See Circle.
Hari	Share cropper; tenant.
Hat	A local public market held at a scheduled time, usually once or twice a week.
Hookah/hukka	Water pipe for smoking tobacco.
Hotar	Land used for rice growing.
Hujra	A common sitting place for males in the villages specially in the former North Western Frontier Province of Pakistan.
Id	Muslim festival.
Idgah	Place where the Id prayers are said.
Imam	The one who leads the prayer of Muslims.
Islamiat	Islamic theology.
Isopercentual	Lines on a map connecting points of equal percentage, i.e. as used in this report, lines connecting equal points of percentages of annual precipitation occurring during the monsoon season.
Jagirdar	A title for the owner of land/land granted permanently by government (British) as a reward for special services to the Colonial Government.
Jamma	Small pieces of brick, usually broken by hand hammer in the Comilla area; it is used in concrete making in lieu of gravel.
Jhalar	Form of Persian wheel used for lifting water from shallow wells.
Jhallari	Land irrigated by Jhallaries - a water wheel lifted on the bank of stream water course.
Jirga	A council of elders.
Kabaddi	A village game generally played in the rural areas of Pakistan.

Kabigan	A style of singing in which two song leaders take opposing sides of a question.
Kachcha	Mud-made houses or unpaved roads.
Kallar	Salt-affected soil.
Kammi	A broad category that includes the non-agriculturalist castes, i.e., craftsmen or unskilled laborers. Every kammi caste has a distinct social and economic function in the village. Kammis are stratified within their own caste group.
Kanal	One-eighth of an acre.
Kankar	Calcium carbonate concretions in the soil.
Kapas	Seed cotton.
Kardar	Revenue official of former Sikh Government.
Kareze	The system of underground storage and distribution of water in wells and covered canals for irrigation and domestic uses.
Kas	A small river or large creek generally, but not always, perennial in flow.
Kashtriya	A Hindu caste next to Brahmin in hierarchy. They have the divine assignment of defending the country.
Kasola	Hand tool used for hoeing.
Khadi	Hand-woven cloth made of hand-spun yarn.
Khal	A canal, or drainage channel.
Khan Sahib/Khan Bahadur	Official titles given to the chiefs and respectable persons, during British rule in India, for outstanding service.
Kharaba	Crop failure.
Kharif	Summer growing season from April to September. Also applied to the crops grown during the monsoon season.
Khasrah (Canal)	The field measurement book in which the Patwari records the final measurement of the irrigation made; it is combined with the initial record (Shudkar).
Khasrah-Bandobast	The register of field areas made at the settlement of the distric .

Khata	A holding; estate.
Khatauni	The demand statement of canal revenue sent to the Deputy Commissioner showing the recoveries to be made from each cultivator.
Khatedar	Small landowner.
Khichri	A dish of whole wheat, rice, pulse, and spices.
Kila/Killa	1.1 acres.
Kirar	Name given to Hindu shopkeeper and money-lender in the Western Punjab.
Kotwali	Police headquarters; usually refers to the thana (county) in which the district office is located.
Lakh/Lac	100,000 punctuated thus: 1,00,000.
Lambardar	Village headman (see also Numberdar).
Las	Land lying in a depression.
Lassi	Buttermilk, milk after removal of butter.
Madrassa	A traditional Muslim school where much of the instruction is based on the Quran.
Mai-Bap	Mother and father, parents.
Maira	Light-textured soil.
Makhdoms	Literally means "One who is served," used as a family name.
Makhlut	Mixed crops.
Maktab	School run by Imam at Mosque. Quran is learned, no other subjects taught.
Maktab Education	Traditional schools of Islamic education.
Malguzar	A land-owner.
Mandal	Committee.
Mandi	Market.
Mansabdar	Holder of a title during Mughal rule in India.
Marla	One hundred and sixtieth of an acre (1/160 acres).

Maund	Unit of measure (= 82.3 lb.).
Mauza	A village.
Milad	The birth Anniversary of the Holy Prophet Mohammad.
Mirs	"Chief" a family name.
Mogha	An outlet.
Moshaira	A symposium where poets recite their poems.
Mullah	A man who is the head of a mosque; ideally, he has had training in Muslim law and doctrine (See Imam).
Munah	Plough, form of local plough used in the Punjab.
Muntakhib	See Khatauni.
Murrabba	The square into which the land of a canal colony is divided, 25 acres of land.
Nabud	A crop where the seed has failed to germinate.
Nahri	Land irrigated from canals.
Nallah/Nullah	Watercourse filled during flood period.
Naib Tehsildar	Assistant revenue officer (See Tehsil).
Najaiz Abpashi	Using water in an unauthorized manner -- vide section 33 of Canal Act VIII of 1873.
Natch	Dancing.
Nawab	"Sub-king" formerly ruler of a state. Urdu equivalent of an Indian Raja.
Nekmard	The gentleman.
Numberdar	Village headman generally responsible for collection of state revenues.
Pabi forests	Forests in the Pabi hills.
Paddy	Unhulled rice.
Pan	A mascatory green lef, commonly chewed with betel nut and lime, grown in East Pakistan.
Pansali	An employee of the irrigation department at village level who controls the quantity of water in a channel.

Panshayat	A formal or informal village body generally responsible for settling village disputes.
Parcha	A slip of demands given to the cultivator or outlet for rain water from the roof in rural areas.
Pardah	Literally, a veil: metaphorically, concealment.
Partal Kham	The checking of the initial record by inspecting the record on the spot to see that all irrigated land is entered and that all the fields that are entered have been irrigated.
Partal, Pacca	The checking of the final field measurement book (kasrah) by remeasuring the irrigated area.
Patidari	A form of village tenure.
Patti	The next most important social grouping for a villager after his caste. Originally, it was an administrative division of the village for the collection of revenue. The revenue authorities appointed one member of the families who have an immediate ancestor in common, for this purpose, and he was called Lambardar. All such families, with the Lambardar at their head, constituted one patti. In a village there can be one or more pattis, usually each having its own lambardar. Gradually, this has become a distinct social group.
Patwari (Canal)	Primarily responsible for the distribution of water including the division of water, timing of water, and related aspects.
Patwari	Minor official of Revenue or Irrigation Department or village accountant.
Pir	Spiritual leader of Muslims.
Potwar	A deeply eroded plateau comprising a part of the Punjab uplands in north-central West Pakistan. A major portion of the study area for the U.S. Watershed Management Team was represented by the Potwar Plateau.
Por or Pore	A seed tube with funnel-shaped mouth attached behind the plough for sowing.
Pora	Sowing with the por. In pora method of sowing the same man controls the plough and drops the seed.
Pukka House	A house made of finished bricks.

Purdah	Seclusion of women from public observation, common among the rural Muslims of South Asia.
Quran	The sacred book of the Muslims, the Koran; the Bengalis prefer this old spelling.
Rabi	Winter cropping season (mid-October to mid-April).
Rakh	Scrub forest.
Rajput	A tribe in India.
Rakkar	Steeply sloping unfertile land.
Ramadan (sometimes spelled Ramazan)	The ninth month of the Muslim (lunar) year, with fasting practices from dawn to sunset.
Rauni (Punjab)	Watering applied shortly before sowing.
Rej (Sindh)	Pre-sowing watering.
Roni (R	An application of irrigation water to the soil sufficient to sprout the seed. Applied to areas where natural rainfall then may be sufficient to produce a crop.
Roznamcha	A diary of work done. In this Manual the Zilladar and Patwari are asked to submit such diaries.
Rupee	Unit of currency in Pakistan. It is made up of 100 paisa. A rupee has been valued at approximately U.S. $0.21 for the entire period covered by this study. For rough approximation, therefore, rupees may be converted to dollars by dividing by five.
Sabuj Sangha	A youth club of school children, generally similar to the 4-H Club or the Future Farmers of America.
Sahukar	Professional money-lender.
Sailabi	Term used in the former Punjab, Bahawalpur State and North West Frontier Province areas of West Pakistan for lands and crops irrigated by flood water from rivers.
Sailab	A form of flood irrigation which is restricted to the active flood plains. Crops, mainly wheat, are planted after the recession of the summer flood waters. Lands under sailab irrigation retain their productive capacity indefinitely and the method is still employed in reverine areas, most of which are not served by canals.

Sailaba	Term used in former Sind, Khairpur State areas and the Kachhi Plain of West Pakistan for lands and crops irrigated by flood water from rivers or by sporadic flow from torrents.
Sansi	A caste without any codified religion. They speak a special language. Usually, they are economically depressed. Many have embraced Islam and are called "Dendars."
Sardar	Tribal chief.
Sari	A woman's garment of approximately six yards cloth. It is draped so that one portion forms a skirt and the other end a covering for the waist and head.
Section	The group of villages which form the charge of one Zilladar.
Seer (Sair)	A unit of measure equal to one fortieth (1/40) of a maund or approximately equal to 2 lb.
Sem	Waterlogging.
Settlement	Periodic revision of land revenue assessment.
Shah Nehri Land/ Shahnehri	Part of a three-fold land classification scheme of the revenue department. Shah Nehri is land irrigated by government canals; Sailaba is irrigated by floods, and Barani is rainfall fed areas.
Shair Mumkim Land	Land not available for cultivation.
Shaita paddy	A seasonal rice crop grown in the winter; it is usually sown broadcast in the Comilla area.
Shajra	The field map of the village made at the settlement of the district.
Shakar	Raw sugar in powdery form.
Shamlat	Village common land.
Sheikh	A family name with respectful connotation.
Shudkar	The initial record of irrigation made by the Patwari as the crop is sown. The book in use for this purpose combines the initial and final measurement.
Shudra	Lowest ladder in the Hindu caste hierarchy, the untouchables.
Sirkar	Government.

Sohaga	Planking and leveling ploughed land to compact the soil and break up clods. The practice also may conserve as much as 33 percent of the soil moisture.
Sohagi	Smaller sohaga worked by one pair of bullocks.
Square	A unit of land in a canal colony measuring either 25 or 27.8 acres.
Subedar	Governor or a province appointed during Mughal rule.
Sultan	Sovereign of a Muslim state.
Syeds	Descendants of Mohammad, are regarded as highest caste among Muslims.
Taccavi	Pertains to the traditional system of providing government loans in times of distress and emergencies. It was first systematized and regulated under the British-Indian Government with the Land Improvement Loan Act of 1883 and the Agriculturist Loan Act of 1884. The distribution of loan funds is the responsibility of the Deputy Commissioner.
Tahika	A territorial unit of civil administration; a subdivision of a district.
Tahsildar	A revenue officer of a subdivision of a district in Pakistan.
Talaf	A crop which fails completely after germination.
Taluqa	A revenue sub-division of a district in former province of Sind, similar to tehsil in other areas.
Tanaza	An objection to assessment. See rule 70 of the rules issued under the Canal Act, VIII of 1873.
Tatil	The period of closure of an irrigation channel.
Tehsil/Tahsil	A revenue sub-division of a district.
Tehsildar/Tahsildar	An executive officer in charge of a Tehsil.
Thana	A police station in West Pakistan and a sub-division of a district in East Pakistan.
Thanedar	A rank of police officer, in charge of a police station, usually with the rank of a sub-inspector.
Thur	Saline soil indicated by visual appearance of salt at the soil surface or crop failure or both due to salinity and alkalinity in the rooting zone.

Thur juzvi	Cropped land on which patches of thur occur.
Thur nau	Formerly cultivated land gone out of production because of thur within five years before the survey.
Thur panjsala	Formerly cultivated land gone out of production because of thur longer than five years before the survey.
Tirphali	Three-tined hoe.
Tonga	Two-wheeled horse drawn passenger carriage. Also used for transport of produce.
Ulema	Muslim religious leaders.
Unani hakim	Local doctor who has received his training at a Unani Tibbia college.
Vadera	A designation for landlord.
Vaishas	Next to Kashtriya in Hindu caste hierarchy, the traders.
Vattar	Right moisture condition of the land for ploughing after rain or irrigation.
Wadh Watter	A crop sown in the moisture left by the last irrigation, e.g., gram sown after chari or rice.
Wahn	Condition of land after harvest.
Wari	A term used in reference to the time a share of the water is taken in an irrigating channel.
Wora-Bandi	The scheme or list of rotational turns or times at which each share-holder in a water-course obtains his supply or each outlet in a distributary is allowed to be open.
Waqaf	Property donated by the owner for charitable purposes.
Wara	Verg; to turn off.
Watt	Irrigation ridges.
Watbund (Wattbundi)	Small ridges of earth constructed to facilitate irrigation, water spreading or water storage within a field.

Water course	A tertiary field distribution segment of the water system. The distribution system is classified as the main canal, branches and distributaries, minors and sub-minors, and water courses and field channels. The governments' responsibilities cease at the outlet which lets the water into a water course reaching the fields through the field channel, where the responsibility passes to the farmers.
Wattbundi	Narrow based, earth banked terrace.
Zamindar/Zemindar	A farmer. May be owner or tenant.
Zari singers	Folk singers in Bengal. These performers often compose songs for special occasions, and may answer a question by improvising a song.
Zilladars	Non-gazetted revenue assistant whose principal functions are assessment of land revenue and water rates, providing assistance in the preparation of warbandis, and the investigation of complaints.
Zamindara	Pertaining to Zamindars.

8.2 Pakistan Organizational Names and Acronymns

ADB:	Agricultural Development Bank
ADC:	Agricultural Development Corporation
Agriculture Consultant:	International Land Development Consultants N.V., and Hunting Technical Services Ltd.
Study Group:	A group of staff members of the International Bank for Reconstruction and Development assigned to assist Dr. Lieftinck in the executive of the Indus Special Study.
Binnie:	Binnie & Partners, Consultant to WAPDA
Coode:	Coode & Partners, Consultant to WAPDA
CTM:	Chas. T. Main International, Inc., Dam Sites Consultant to the Study
Dam Sites Consultant:	Chas. T. Main International, Inc.
Gibb:	Sir Alexander Gibb & Partners, Irrigation Consultant and coordinator of consultants to the Study.
GOP:	Government of Pakistan
Harza:	Harza Engineering Company, International, general engineering consultant to WAPDA
HTS:	Hunting Technical Services Limited, Agricultural Consultant to the Study.
IACA:	Irrigation and Agriculture Consultants Association
IBRD:	International Bank for Reconstruction and Development (World Bank)
IGC:	Indus Gas Company, which distributed Sui gas in the Sind (Sukkur, Hyderabad, etc.)
ILACO:	International Land Development Consultants N.V., Agricultural Consultant to the Study.
Irrigation Consultant:	Sir Alexander Gibb & Partners

KESC:	Karachi Electric Supply Corporation, Ltd.
KGC:	Karachi Gas Company, which distributes Sui gas in the Karachi area
LIP:	Lower Indus Project: regional study carried out by Hunting Technical Services Limited and Sir Murdoch Macdonald & Partners
LWDB:	Land and Water Development Board
MESCO:	The Multan Electric Supply Company, Ltd.
PMS:	Power Market Survey Organization
Power Consultant:	Stone & Webster Overseas Consultants, Inc., Power Consultant to the Study.
REPC:	The Rawalpindi Electric Power Company, Ltd.
SCARP:	Salinity Control and Reclamation Project
SGTC:	Sui Gas Transmission Company, responsible for transmitting gas from Sui to the South.
SNGPL:	Sui Northern Gas Pipelines, Ltd., responsible for transmitting Sui gas to the North and distributing it and the gas from Dhulian field there.
S&W:	Stone & Webster Overseas Consultants, Inc.
TAMS:	Tippetts-Abbett-McCarthy-Stratton International Corporation, Consultants to WAPDA on Tarbela Dam
T&K:	Tipton and Kalmbach, Inc., Consultant to WAPDA
WAPDA:	Water and Power Development Authority of West Pakistan
WASID:	Water and Soils Investigation Division (of WAPDA)

8.3 Pakistani Measurements

Acre	One acre consists of 0.8361255 hectares. In Pakistani measurement 2 Bighas or 8 Kanals make up an acre.
Bigha	One Bigha equals 2,000 square yards of 1.672 square meters. In Pakistani measurement one Bigha is made up of 4 Kanals.
Chattak	One Chattak equals 0.103 pounds or 0.466 kilograms. In Pakistani measurement it equals 5 Tolas.
Crore	A crore signifies one hundred lakhs (of anything) and is written 1,00,00,000 or 10 million. A crore of rupees (in figures Rs. 1,00,00,000) is equal in current official rates of exchange to U.S. $2,100,000 or L 850,000 sterling.
Kanal	One kanal equals 500 square yards or 418 square meters. In Pakistani measurement a Kanal is made up of 20 Marlas, one-eighth of an acre.
Lakh	A lakh signifies 100,000 (of anything) and is written 1,00,000. A lakh of rupees (in figures Rs. 1,00,000) is equal at current official rates of exchange to U.S. $21,000 or L 8,500 sterling.
Marla	One marla equals 25 square yards, or 20.9 square meters.
Maund	One standard maund or 4 seers equals 82.21 pounds or 37.3 kilograms.
Murrabbah	A square of land equalling 25 acres or 10.125 hectares in extent.
Rupee	Amount of currency in Pakistan worth .21 cents in U.S. currency and 21 pence in British currency. The Rupee is divided into one hundred paisas.
Pao	One pao equals 0.514 pounds or 0.233 kilograms. It equals in Pakistani measurement 4 chattaks.
Seer	One seer equals 2.057 pounds or 0.933 kilograms. It equals in Pakistani measurement 4 paos.
Tola	One tola equals 0.40 ounces or 11.3 grams.

8.4 Names of Trees and Plants

Pakistani Name	Common English Names		Latin Name
Alu bokhara	Plums	Plums	Prunus domestica
Amrood	Guava	Guava	Psidium guayava
Angoor	Grape	Grape	Vitus Vinifera
Aru	Peaches	Peaches	Prunus persica
Arvi	Arum	Arum	Colocasia antiquorum
Badam	Apricot	Apricot	Prunus armeniaca
Babul/kikar	Almond a tree		Acadia arabica = A. nilotica
Baingan	Brinjal	Egg plant	Solanum melongena
Bakain			Melia azadirach
Bandgobhi	Cabbage	Cabbage	Brassica oleracea
Banyan			Ficus bengalensis
Ber	A kind of plum		Ziziphus jujuba
Bhindi	Lady finger	Okra	Hibiscus esculentus
Bombax/semal			Salmalia malabarica
Chana	Gram	Gram	Cicer arietinum
Chari	Jowar	Sorghum	Andropogon sorghum
Chir pine			Pinus longifolia Roxb.
Farash			Tamarix aphylla/ articulata
Gajar	Carrot	Carrot	Dancus carota
Garjan			Conifer
Haldi	Turmeric	Turmeric	Cucurma longa

Pakistani Name	Common English Names		Latin Name
Jam	Jam	Jam	Eugenia jambolana
Jand/Kandi	Bush	Bush	Prosopsis spicegera
Jantar	Jantar	Jant	Sesbania aegyptiaca
Kail			Pinus excelsa
Kharbooza	Melon	Sweet melon	Cucumis melon
Kheera	Cucumber	Cucumber	Cucumis sativus
Kikar/babul	a tree		Acacia arabica = A. nilotica
Lai			Tamarix dioica
Lassan	Garlic	Garlic	Allium sativum
Loquat	Loquat	Loquat	Eriobotrya japonica
Makai	Maize	Maize	Zea Mays
Malta	Orange	Orange	Citrus dinensis
Mango (Aam)	Mango	Mango	Mangifera indica
Mash	Mash	Mash	Phaseolus radiatus
Mirch	Chillies	Pepper	Capsicum annuum
Mung phali	Groundnut	Peanut	Arachis hypogaeca
Nashpati	Pears	Pears	Pyrus communis
Neem	a tree		Azadirachta indica
Palak	Spinach	Spinach	Beta benghalensis
Phulgobhi	Cauliflower	Cauliflower	Brassica oleracea
Piaz	Onion	Onion	Allium cepa
Pipal	a tree		Ficus religiosa
Rawan	Black-eye beans	Cowpeas, Black-eye beans	Vigna sinesis
Seb	Apple	Apple	Pyrus malus

Pakistani Name	Common English Names		Latin Name
Shaljam	Turnip	Turnip	Brassica rapa
Shehtoot	Mulberry		Morus alba
Shisham	a tree		Dalbergia sissoo
Siris	a tree		Albizia lebbek
Soybean	Soybean	Soybean	Glycine hispida
Tamatar	Tomato	Tomato	Lycopersicum esculentum
Tarbuz	Watermelon	Watermelon	Citrullus vulgaris
Wan			Salvadora oleoides
White siris			Albizia procera

8.5 Names of Pakistani Crops

Local and Latin Names of Crops

Local	Common Description	Latin Name
Arhar (K)	pigeon pea	Cajanus indicus
Bajra (K)	spiked millet	Pennisetum typhoideum
Berseem (R)	Egyptian clover, fodder crop	Trifolium alexandrinum
Bhabbar	a grass	Eulaliopsis binata
Chari/jowar (K)	sorghum	Sorghum vulgare
Chhembhar (K)	fodder grass	Eleusine aegyptica
China (K)	a coarse millet	Panicum miliacium
Dub	a grass	Cynodon dactylon
Gram/Chana (R)	Gram, a pulse	Cicer arietinum
Guara (K)	field vetch	Cyamopsis psoralioides
Hathi ghas	Napier (elephant) grass	Pennisetum purpureum
Jhambo (R)	oilseed	Eruca sativa
Jowar/chari (K)	sorghum	Sorghum vulgare
Kangri (K)	a coarse millet	Setaria italica
Kulath (K)	a pulse (legume)	Dolichus biflorus
Mash (K)	a pulse	Phaseolus radiatus
Massar (R)	lentil	Lens esculentus
Mattar (R)	peas	Lathyrus sativus
Moth (K)	pulse	Phaseolus aconitifolius
Mung (K)	a pulse	Phaseolus mungo
Napier grass	Napier or elephant grass	Pennisetum purpureum
Okra/Bhindi (K)	Ladies finger, okra	Hibiscus esculentus

Raya (R)	oilseed	Brassica juncea
Sarson (R)	oilseed, Indian Colza	Brassica campestris
Senji (R)	sweet clover	Melilotus parviflora
Shaftal (R)	Persian clover	Trifolium resupinatum
Sudan grass	Sudan grass	Andropogon sorghum
Swank (K)	millet	Panicum colonum
Taramira (R)	oilseed	Eruca sativa
Til (K)	sesame, Sesamum	Sesamum indicum
Toria (R)	oilseed	Brassica napus

K = kharif
R = rabi

Informational Sources for Water Management for Agricultural Production in Pakistan: With Special Reference to Institutional and Human Factors

VOLUME II

by

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of the Less Developed Countries

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Introduction

The published and unpublished research on water management is overwhelming. Just a decade ago the literature was slight and the annual output relatively small. However, with the beginning of the 1960's there occurred a widespread interest in water management and a virtual avalanche of materials resulted. There is no easy way to deal with this problem. At several institutions, special collections have been started; new information retrieval systems are being developed, and numerous specialist bibliographies prepared.

For over one year we, along with others, struggled gamely with this problem. We tried to be selective and innovative. However, we accomplished neither. The problem was beyond our research resources. A computer information retrieval system is the only solution. We hope that we have offered some suggestions in this area.

Garth N. Jones assumed the primary responsibility for preparing the bibliographic section on Pakistan. Robert Schmidt did the same for the non-Pakistan bibliographic section as well as the compilation of journals and periodical literature. As indicated in the introduction to Volume I, Messrs. Jones and Schmidt were assisted by a number of persons. Again we wish to acknowledge their assistance, without which this undertaking would have never been completed.

Garth N. Jones
Robert Schmidt
February 1973

INFORMATIONAL SOURCES FOR WATER MANAGEMENT FOR AGRICULTURAL PRODUCTION IN PAKISTAN: WITH SPECIAL REFERENCE TO INSTITUTIONAL AND HUMAN FACTORS

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WATER MANAGEMENT BIBLIOGRAPHY

9. PAKISTAN

9.1 Bibliographic Essay

by

Garth N. Jones

Irrigated agriculture, even under its simpler conditions, is an exceedingly complex activity. It requires a thorough understanding of its natural environment, considerable organizational capability, major capital investment, high level scientific knowledge and technology, substantial human effort, stable political order, and effective management skill. Its requirements approach that of an industrial society. Irrigated agriculture can only be conceived within the framework of organizational analysis of a complex socio-technical system that is harmoniously functioning in relationship to its natural environment.

In complex system terms irrigated agriculture demands three general perspectives: (1) the natural, (2) the technological, and (3) the human and institutional. The last two perspectives are the means by which to mobilize the forces and the pecularities of nature in a given region to meet man's needs for food and fiber.

All three perspectives can be visualized as organizational or system components which are constantly interacting with each other and constantly adapting and changing over time both their external as well as their internal working relationships. By the introduction of knowledge, technology, capital, and human effort the environmental or natural component can be drastically changed, as any well established irrigated agricultural economy illustrates.

Thus, any study of irrigated agriculture must take into account all three perspectives. A bibliographical treatment of the literature as well cannot be any less specific without running the risk of making grave errors and drawing eroneous conclusions.

However, the complexities of irrigated agriculture defies such an approach or treatment; and this is especially the case with the vast Indus basin irrigation system in West Pakistan which commands nearly 30 million acres and provides a livelihood for over 40 million people. Specialization becomes an imperative in gaining a mastery of understanding the more complex system.

This bibliography is designed in specialist terms. It centers primarily on the human and institutional component of irrigation development and management in West Pakistan. References from the two other components are included only to the extent necessary to provide balance and insight into the total irrigation complex or to clarify a particular segment of the system.

The references are placed into five broad categories. The first deals with the setting or the configuration of the irrigation system. This category can be regarded as including the "givens" of the system or the basic factors within the irrigation system construct. The planners and the administrators have little choice but to accept these "givens" or factors, as they are found. Once the decision is reached to distribute a certain percentage of water between a particular set of canal linkages, this becomes a relatively permanent feature of the system over which the irrigation managers have little control and must learn to live with. Historical decisions concerning the distribution of water are just as much constraining factors as the historical hydrologic flows.

The second category is primarily concerned with the operational characteristics of the system. How is the water delivered and the excess water removed? What are the institution control and regulating devices? The third category is directed toward the problem of how to change and improve the irrigation system. This includes both its basic structure as well as its operating procedures. The fourth deals with specific problems or subjects that require comprehensive investigation such as the administrative capability for development, projected food supplies and nutritional needs, and special case studies of regional development.

The fifth or last category is a "bibliography of bibliographies:" Where and how to find information and data on Pakistan's irrigated agriculture.

West Pakistan's irrigated economy is essentially a product of centralized and planned development.[1] It represents the confidence of the Nineteenth Century Western man's effort and aspiration to gain mastery over his natural environment and to rationally intervene and resolve social problems. The irrigation system was designed to alleviate famine conditions and to spread the maximum benefits possible to the inhabitants in a particular region. Jeremey Benthan's humanitarian philosophy of the "greatest good for the greatest number" was very much evident.

The social action and intervention was almost solely based upon a priori considerations, "arm chair" reasoning and intuitive decisions. Empirical research was not widely conducted and emerging problems seldom anticipated.

[1]This is very well indicated in the excellent survey of the documentary literature of the Punjab from 1843-1947 by Professor N. Gerald Barrier. This is an invaluable reference and many of the appropriate items noted in this bibliography have been included here. See his Punjab History in Printed British Documents, A Bibliographic Guide to Parliamentary Papers and Select, Nonserial Publications, 1843-1947, Columbia: University of Missouri Press, 1968.

In the early 1940's, deterioration of the irrigation system was becoming increasingly evident.[2] By the early 1950's it reached alarming dimensions, with an acre of land going out of production every five minutes. At this rate nearly 120,000 acres of land a year were being lost to water logging and salinity.[3]

The practice of extensive irrigation, the spreading of the irrigation water over as many acres as possible and which appeared to the 19th Century engineer planner and administrator to be a very rational course of action, represented the introduction of an infectious cancer that would eventually require drastic remedial measures. The vast irrigated areas of the Indus basin which in the 19th Century was sparsely inhabited by the middle of the 20th Century was densely populated with a people reproducing at a rate approaching three percent per year. The social and engineering problems appeared, and still do, almost insuperable.[4] Nevertheless, in the mid-1950's action was initiated to correct the situation. This culminated in the gigantic Indus basin development program.[5] Again the planners and the administrators sought an engineering solution to resolve the pressing social crisis of famine and social disorder.

In the mid-1960's irrigated agriculture in West Pakistan, largely with World Bank assistance, for the first time was studied to some depth. Although the investigations were heavily oriented in the terms of engineering design and economic productivity, substantial field studies and reports on the social and institutional facets were prepared. Large amounts of data, herebefore unavailable, were collected, and some of this analyzed and published.[6]

The several dimensions of this tremendous irrigation system for the first time was "mapped out," and in cases explored to some depth.

These studies, following the lead of earlier ones, characterize West Pakistan's agriculture as being caught in a vicious circle of low water supply and a low level of agriculture production, and point out that to a

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[2]See especially Aloys Arthur Michel, The Indus Rivers: A Study of the Effects of Partition (New Haven: Yale University Press, 1967).

[3]*Ibid.*

[4]See especially Pieter Lieftinck, A. Robert Sadove, and Thomas C. Creyke, Water and Power Resources, A Study in Sector Planning, three volumes (Baltimore: Published for the World Bank as Administrator of the Indus Basin Development Fund by the Johns Hopkins University Press, 1969).

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[6]*Ibid.* Also see the background data reports prepared by Sir Alexander Gibb and Partners, International Land Development Consultant , and Hunting Technical Services (London and Arnhem), Programme for the Development of Irrigation and Agriculture in West Pakistan (Washington: International Bank for Reconstruction and Development, 1966), 23 volumes.

considerable extent these two are closely related. The fundamental task is to redesign the irrigation system to break this cycle.[7]

An increase in the supply of water is not sufficient in itself to break this vicious circle. The practice of under-irrigation or extensive spreading of the irrigation water is based upon one hundred or more years of history. Major social changes will be required.

The difficulty in dealing with this problem and related ones is that the irrigation system was never designed or has ever been studied within "holistic" system terms. The paradox is found where a large modern organizational system delivers water to a certain point where it becomes the sole responsibility of a very traditional social order to determine its use. How water is used to grow crops over long periods of time is a much more difficult problem than water delivery. However, this fact has never been fully realized in most irrigated systems including that of Pakistan, and certainly little in the way of technical assistance has ever been given to the traditionally-ladened farmers upon whom fall the principal burden of increasing agricultural productivity.

Increasingly, it is becoming evident that the gross imbalances between the technological and the human and institutional capacities must be reduced. The great increases in the future productivity of West Pakistan's irrigated agriculture will undoubtedly be made by strengthening the technological component. This is going to be a much more difficult proposition than the recently completed technological changes. Social science research has never received much attention in irrigation development including West Pakistan. Vast information gaps exist.

Planners and administrators can no longer afford the luxury of intuitive decisions, since the substance which they are now working with are people. People cannot be molded and twisted like the vast engineering works of the Indus plains. They have the capacity to quickly respond and to destroy!

Then, of course, the end purpose of this tremendous development is to enhance the quality of life of the people. The quality of life constitutes much more than the securing of "adequate bread," and it can be enhanced only by constructive social intervention based upon sound information and research. More field studies are needed like the recent "Socio-Economic Bench-Mark Survey of the Mona Project" by Ali M. Chaudhry, Haider Ali Chaudhari, M. Rafique Raza, and A. R. Rizwani.[8] Such studies are expensive and require sophisticated social science research talent.

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[7] See Garth N. Jones and Raymond L. Anderson, "The Problem of Under-Irrigation in West Pakistan: Research Studies and Needs," Water Management Technical Report No. 8, Fort Collins: Water Management--Cususwash, Colorado State University, 1971 (processed).

[8] Issued by the West Pakistan Agricultural University, Lyallpur, in 1966-67.

The area of water pricing has scarcely been investigated. Such studies as Paul W. Paustian's Canal Irrigation in the Punjab published in 1930 provide a much needed historical foundation.[9]

The behavior of the Pakistani farmer needs to be better understood. Sir Malcolm Darling's classic, The Punjab Peasant in Prosperity and Debt,[10] provides some research guidelines in this area.

The organization and management of the canal irrigation system has received only light treatment, and the information that does exist is scattered throughout numerous articles and unpublished consultant papers.

The water and land law is largely a product of administrative rules and procedures, and is inadequate for a nation developing a modern agriculture as well as facing major urban and industrial problems. This area is almost totally unresearched.[11]

Local water user organizations appear to be entirely missing in West Pakistan or at the best very primitive institutions. This could be the crucial missing link in further development of West Pakistan's irrigation system.[12]

In sum, while a few noteworthy social science studies can be found, insufficient knowledge make it extremely difficult to advance any constructive social interventio. program. A major research effort along the lines of the numerous engineering investigations is urgently needed and long overdue.

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[9] New York: Columbia University Press, 1930.

[10] London: Oxford University Press, 1925.

[11] About all that can be found are legal compilations such as the one by Ch. M. Hussain Jahania, The Canal and Drainage Act, with Rules and (i) Minor Canal Act and (ii) Soil Reclamation Act (Lahore: The Mansoor Book House, 1968).

[12] See Garth N. Jones, "Evaluation of Local Irrigation Institutions: The Systems Approach," Fort Collins: Water Management Program, Colorado State University, 1971 (processed).

Editor's Note

As shown in the Table of Contents, this bibliography has been organized under five major categories which are in turn divided into a large number of minor categories. The headings of all the major categories and the minor categories are retained in this bibliography, even though in several cases no appropriate citations were found or the research is referred to a more general bibliographical series prepared by Garth N. Jones and Shaukat Ali.[1]

This bibliography was organized in several ways in order to facilitate the quick retrieval of information and data. First a detailed table of contents was prepared. When necessary items were classified up to three major or minor categories. If the item was classified in other categories, this fact is noted on each referenced item. For example, see Aloys Arthur Michel, The Indus River, A Study of the Effects of Partition (New Haven: Yale University Press, 1967), which is classified under the following numbers: 1.131, 3.25, and 3.39.

Second, a large number of the items are annotated. If the item was also placed under two or three other categories, the category where the annotation may be found is noted in each of the insertions.

Third, all items have been numbered consecutively. A few items, added after the bibliography had nearly been completed, have been placed in their proper order by the use of decimal numbers to expand the system (e.g., 130.1 could be placed between 130 and 131). Some numbers are skipped (e.g., for example 155) because the items were deleted or shifted to another section. In no cases are there duplicate numbers such as two citations numbered 120.

Fourth, the entire bibliography has been indexed by the author or by the institution which issued the work. The index notes the item numbers under which an author's entries may be found. Stars (*) indicate joint authorship. If the item number is underlined, this signifies that it was annotated such as Sayeed, Khalid - 208.

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[1]See A Comprehensive Bibliography, Pakistan Government and Administration (Lahore: All-Pakistan Public Administration Centre, 1970). Volume Two was prepared by Garth N. Jones and published in 1972 by the Peshawar Academy for Rural Development. Volume Three has also been prepared by Garth N. Jones and will again be published by PARD.

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65. Correspondence as to Prosecution of Irrigation Works from Capital Raised by Loan; Reports of Progress; Revenue Reports of Irrigation Departments of Governments of North-West Provinces and Punjab, with Orders of Governments of India; Report by Colonel Strachey, 1870, sess. 389, 53:3 (202).
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Minutes of Evidence Taken Before the Royal Commission upon Decentralization in Baluchistan, the North-West Frontier Province, and the Punjab, 1908, Cd.4368, 46:423 (278).
Annotation follows on next page.

The Commission examined relations between the Indian and subordinate governments and suggested widening of provincial authority and discretionary power. The report surveys the history of British administration, with special reference to finance, civil service, public works, the function of district officers, rural boards, and municipal committees. Evidence from the Punjab includes minutes and proceedings which supplemented other Punjab data in the report. Several non-official interviews bear on communalism and reflect increasing Punjabi hostility toward the British; appendices on the organization of the Punjab "raj" and the views of officers on decentralization afford insight into the institutional and ideological background of the Punjab cadre.

73. Despatch from the Government of India to the Secretary of State, 9th March 1865, with Enclosures on the Subject of Irrigation Works, 1866, sess. 207, 52:375 (19).

Despatches on the Subject of Irrigation in India Generally Since the Transfer of the Government of India to Her Majesty, 1867, sess. 105, 105-I, 50:475 (74).

Policy discussion concerning repair of existing works, construction of new ones, and whether such canals should be the responsibility of the government or should be transferred to private organizations. Besides supplying information on Punjab canals, the documents are significant because they bear directly upon future Punjab irrigation projects.

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The two Douie manuals remain the most concise printed sources on the evolution and functioning of the Punjab revenue system. Both are annotated with references to records, revenue history, and judicial decisions. The Administration Manual was printed first in 1908, and despite some rearrangement and deletion of noncurrent material from parts of the original text, the historical sections in the recent Pakistan edition remain intact. The first part deals with rural society and rural legislation, with detailed data on landlord-tenant relations, jagirs, and landholding patterns. The second part discusses the organization of the land system; the third, agrarian statistics and the record of right; the fourth, collection of revenue; the fifth, state aid to landholders; and the sixth, state land and the disposal of "wasteland." The Settlement Manual was first published in 1899 as a guide to settlement staff officials, replacing the Barkley

and Cust handbooks. The third edition, prepared by A. H. Diack in 1915, is the basis for the current Pakistan edition. The first half is primarily an historical survey of the Punjab revenue system; the second discusses technical problems such as records, settlement, and protection of tenants.

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78. Dutt, R. C., Economic History of British India, London: 1902.

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82. Famine Commission, 1880 (Strachey), Report of the Indian Famine Commission, 1880, 1880, C.2591, 52:387 (92).

83. Further Report of the Indian Famine Commission, 1880. 1880, C.2735, 52:479 (151).

84. Further Report of the Indian Famine Commission, with Proceedings, Evidence, and Appendices. 1881, C.3086, 71 pts. 1-3 (appr. 1873).

The 1876-1880 famine affected only a few Punjab districts, but the report and evidence volumes contain useful data on Punjab social and economic life. Sections on famine history and "conditions of the people" include agrarian statistics, discussions of land revenue, debt, tenantry, railways, and industry, along with several lengthy reports from the Punjab government. Other sections on relief and prevention of famine re-examine irrigation history and suggest additional support for proposed Punjab public works.

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Papers Regarding the Famine and the Relief Operations in India during 1900-1902, 1902, Cd.1179, 70:703 (546).
Punjab reports and evidence are integrated into the general discussion; monthly reports, correspondence, and assessment of Punjab conditions are found in the collected papers. Additional information on Punjab famine is in Cd.205, 1900, 27:387 (512), and The Punjab Famine of 1899-1900 (7 vols.; Lahore: Superintendent, Government Printing, Punjab, 1901).

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Inquiry after the 1907 Punjab canal colony disturbances. The report contains information on the history of the colonies and an evaluation of the government's role in the life of settlers, but unfortunately the voluminous appendices and evidence in the

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164. Punjab Resources and Retrenchment Committee, 1937-1938 (Manohar Lal), Report of the Resources and Retrenchment Committee Appointed by the Punjab Government, Lahore: Superintendent, Government Printing, Punjab, 1939. (con., iii, 503). BM, IO. DLC.
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Selection of documents on controversial legislation; valuable not only for discussion of revenue and tenancy policy, but also for Punjab agrarian society and landholding patterns. Background may be consulted in G. R. G. Hambly, "Richard Temple and the Punjab Tenancy Act of 1868," English Historical Review, 79(1964), 47-66.

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171. Report of the Indian Irrigation Commission, 1901-03, The, 4 vols., Calcutta: Office of the Superintendent of Government Printing, India, 1903.

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174. Rights of Tenants to Sink Wells, Punjab Review (Lahore), 44(1874), 393-402.

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Annotation follows on next page.

The government circulated these rules after each major amendment to inform officers of the changes and to instruct them concerning new procedure. The volume contains copies of legislation, Chief Court rulings, and instructions on how to handle pending cases. Often new rules and amendments were posted directly into the volumes, although this practice varied with each officer and consequently with each volume or rules. Besides furnishing specific information on land revenue laws, the rules contain sections on zaildars and inamdars that afford insight into political arrangements in the rural areas and into the British attempt to use either elected or traditional leaders for political control.

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build-up and drainage, horizontal versus vertical drainage, and sub-irrigation. The article concludes by stating that insufficient water was not the only deficiency of the Indus Plain and the provision of more water is not the only solution. The authors feel that insufficient attention is being given to the other needs of agriculture in West Pakistan. Unless these needs are met the ultimate results of the effort will be disappointing. There are comments by Nazir Ahmad and Frank M. Eaton that follow the article. The comments are followed by a Rejoinder by Ghulam Mohammad.

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One of the most significant phenomena in agricultural development in Pakistan has been the installation of private tubewells by the farmers of West Pakistan at an exceedingly fast rate during the Second Plan period. Installation of these tubewells has enabled the farmers to intensify irrigation and make important changes in cropping patterns in order to maximize the income from their crop production. In this article is presented the results of two surveys conducted on private tubewells and the cropping pattern followed by farmers in areas where tubewells are being installed. The results of these surveys indicate that West Pakistan is likely at attain a rate of increase in agricultural production which will be unparalleled in the history of agriculture. To achieve and maintain such a rate of increase, however, considerable revision will be necessary in the programme for land, water and power development proposed for the next ten years, and that included in the Third Five Year Plan.

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