

THE ROLE OF IRRIGATION IN AGRICULTURE
IN WEST PAKISTAN

by 590

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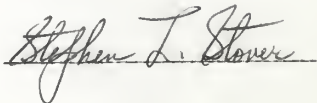
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CHAPTER I

INTRODUCTION

Depending upon the physical and cultural conditions under which it is practised, irrigation can be defined in different ways. However, for the purpose of this study irrigation is defined as the artificial application of water to overcome the deficiencies in precipitation for the growing of crops.

The precise origin of irrigation agriculture is not known, but there is no doubt that it has been in existence for many thousands of years. Irrigation agriculture probably began in Mesopotamia almost seven thousand years ago.¹ Basin irrigation was developed in Egypt even before 3000 B.C., and almost at the same time advanced civilizations of Mohenjo-daro and Harappa based on irrigation agriculture were in existence in a major portion of the Indus Valley. Frequent references to irrigation in the Bible as well as in Atharva-Veda, the ancient Hindu scripture (Atharva-Veda symbolizes a river as a cow and a canal as a calf), indicate that irrigation remained important throughout the ages. There is historical evidence of the respective duties of kings and people in regard to irrigation works, having been defined in some parts of the subcontinent as early as 300 B.C.²

¹R. C. Dinawer (ed), Irrigation of Agricultural Lands (Madison: American Society of Agronomy, 1967), p. 12.

²Ibid., p. 4.

Irrigation, through its promotion of stability of food supply, its stimulation of ingenuity and innovation, and its requirement for organized cooperative efforts, is believed to have been responsible for the existence of earlier civilizations on the face of the earth.

Control of water resources permits the establishment of highly productive agricultural practices and the consequent expansion of human population in areas where rainfall would be inadequate or unreliable. In turn, the operation of a complex irrigation system carries with it certain technological and social imperatives, the ignorance of which may lead to disaster. Extensive irrigation works, where existing, reflect the technological and administrative ability of the civilization they serve and, in turn, have been instrumental in the development of the economy and social life of the people. Changes occurred in the economy and culture of the societies as they developed irrigation systems. New efficiency of food production associated with irrigation resulted in food surpluses that made possible an increased rural and urban population. Greater wealth was accumulated by the ruling classes which frequently was associated with cultural florescence in different parts of the world.

At present, when there are rapidly growing populations and a world food shortage, the expansion of irrigation to increase food production is of crucial importance. In the first half of the present century, the total irrigated acreage of the world nearly tripled.³

³"Irrigation," Encyclopaedia Britannica, XII, 1966, p. 645.

During the last twenty years, the area under irrigation in the world has approximately doubled. But there has not been a corresponding increase in agricultural production, partly because of a general failure to understand the complexity of the problems involved in careful social planning and the mastery of a sophisticated type of farming associated with irrigation agriculture.⁴

Irrigation, however, has to play a strategic role in the continuous process of agricultural development. Because more than three-quarters of the earth's land area lacks adequate natural moisture for successful crop production,⁵ it is believed that improved water management can probably do more towards increasing food supplies and agricultural income in the irrigated areas of the world than any other agricultural practice.⁶

The study of irrigation is of particular interest to geographers. Geographic studies ranging from small individual irrigation projects to the ones covering the world are not uncommon in the literature today. Irrigation is geographic because, on the one hand, there is considerable spatial variation in the types and methods of irrigation found in the world. On the other hand, the landscapes which result from irrigation vary both in extent and degree, and the variations are due to the interaction among complicated factors.

⁴Leonard M. Cantor, A World Geography of Irrigation (Edinburgh: Oliver and Boyd, 1967), p. v.

⁵N. D. Gulhati, Irrigation in the World: A Global Review (New Delhi: International Commission on Irrigation and Drainage, 1955), p. vii.

⁶Dinauer, op. cit., p. ix.

Irrigation devices which have been in use for thousands of years are still being used in certain parts of the world. Along with these pre-historic irrigation practices, one can see today the gigantic irrigation complexes of Aswan Dam, Hoover Dam, Tarbela Dam, and the modern and sophisticated irrigation projects of the Sacramento and San Joaquin Basins in California. This water resources development project of Central Valley California is perhaps the only one of its kind, in which surplus water from the northern Sacramento river, about five hundred miles away, is being transferred for irrigation to the water deficient southern part of the San Joaquin Valley, against the slope of the area.⁷

Differences in the pattern of agriculture are observable wherever adequate irrigation facilities are available. However, the degree to which irrigation has transformed the landscape is greatest in the arid and semi-arid regions of the world, where in some places the contrast between the desert and the sown is one of the most striking of geographical phenomena. In nearly all the major regions, there is a marked difference between the landscape of traditional small-scale peasant irrigation and that of modern, large-scale projects. Because of the expected changes accompanying the introduction of irrigation or changes in the system of irrigation already being practiced, the planners of irrigation enterprises should take into consideration the possible shift from one type of cropping system to another, which might be necessitated by changes in competition or changes in the demand for

⁷Cantor, op. cit., p. 209.

commodities. The cropping pattern as well as the size of the farm, when not considered in advance, have caused complications even in the dynamic economies of Western United States as well as in the Columbia Basin Project in central Washington.⁸

Statement of the Problem

The following study is an attempt to synthesize irrigation, types of irrigation, farm size, and crop pattern in West Pakistan. It is important to mention here that these are not the only elements of the irrigation-agriculture complex of West Pakistan. Some factors equally important in this connection are regional economies, internal and external political impediments, land tenure, and waterlogging and salinity. The justification for selecting a few elements from a complete whole is the time and space limitation. However, reference has been made to each factor wherever it was necessary.

Scope and Limitations

The main purpose of this work is to understand the role irrigation has been playing in the agriculture of West Pakistan. An effort is made to understand this role mainly in terms of space, but in terms of time as well.

Standard works dealing with different aspects of irrigation in the province of West Pakistan are not difficult to find in geographic literature. However, all the research done so far is either limited in areal

⁸Dinauer, op. cit., p. 19.

extent or in scope. Most of the work done concerns some aspects of individual irrigation projects. The studies covering larger portions of West Pakistan, like those of Malik and Michel, cited in the bibliography, are limited in scope in the sense that they have considered only one or two aspects of irrigation. To the best of this writer's knowledge, no study comparable to this one, either in scope or in extent, has been done. The results of this study might be used for future planning and the approach might stimulate future researchers to proceed further along this line.

Insofar as the limitations and omissions are concerned, it should be kept in mind that no geographic research is complete unless it considers every factor of even the least significance. As mentioned earlier, some of the important elements not considered might affect the results. The study has drawn heavily from the 1960 Pakistan Census of Agriculture and so, along with being not up-to-date, its accuracy depends upon the accuracy of the census.⁹ The 1960 Pakistan Census of Agriculture is the first report of its kind. It indeed signifies an appreciable effort but at the same time this census cannot be considered flawless, a fact which the census authorities themselves do accept. However, the information provided in the census is considered valuable and has been gainfully employed by researchers, planners and decision makers.¹⁰ Another factor which might have influenced the accuracy of

⁹The information and statistics used in this study, if not documented otherwise, have been taken from this source.

¹⁰I. H. Zaidi, "The Spatial Pattern of Farm Sizes in the Punjab Region of West Pakistan," Pakistan Geographical Review, XXII (July, 1967), p. 64.

results is the size of the areal units used. The administrative divisions of West Pakistan, called Divisions, are too large to give very precise results. There is also considerable variation in the agricultural pattern within each division. However, to minimize the error, the sub-divisions (districts) within the divisions have been frequently considered, although without giving their precise location.

Methods of Analysis

Each of the elements considered in the study has been discussed in a separate chapter. Each chapter, however, is an inseparable part of the whole thesis, in the sense that the element discussed in each chapter cannot be isolated because due consideration has been given to every factor influencing the where, how, and why of the elements discussed. The chapter dealing with the development of irrigation, unlike the others, is not really a synthesis because the purpose of this chapter is to form a background upon which later chapters have been developed. Synthesizing character is maximum in the fourth and fifth chapters because the elements discussed in these chapters have been greatly affected by each other as well as by the rest of the elements considered in the thesis.

The maps used to show the patterns are revealing. Although the cartographic methods used are not new, some of them, at least, have not been used previously for the area considered in this study.

Whenever it was necessary to insure maximum accuracy, each element was considered in space as well as in time dimension. Wherever possible, regional and topical approaches were jointly applied.

CHAPTER II

DEVELOPMENT OF IRRIGATION

Agriculture and Irrigation

Pakistan is a predominantly agricultural country. Agriculture contributes over fifty per cent of the total national income and gives employment to seventy-five per cent of the civilian labor force. About ninety per cent of the people of the country living in rural areas depend directly or indirectly on this occupation. It is responsible for about ninety per cent of the nation's foreign exchange earning.¹¹ Prosperity of the masses obviously depends upon prosperity of agriculture. A higher standard of living for the farmer is bound to increase his purchasing power and will provide a market for most of the industries that in turn demand agricultural raw material. The province of West Pakistan occupies a special position in this respect. On the one hand, land and water resources are concentrated here, and, on the other, pressure of population is very low as compared to the province of East Pakistan. According to the 1961 census of population, average density of population for West Pakistan was 138 per square mile while that for East Pakistan was 922.

A comparison of irrigation agriculture among the countries of the world shows that Pakistan occupies fifth position according to the total area irrigated. If the ratio of irrigated area to cultivated area is

¹¹S. M. Akhtar, Pakistan - A Developing Economy (Lahore: Publishers United Ltd., 1967), I, 64.

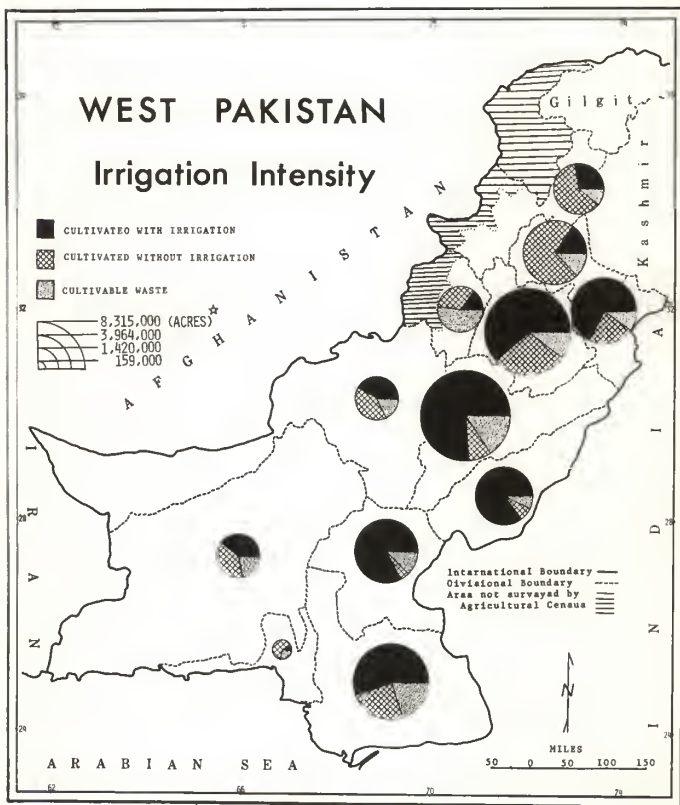
considered, the four countries (China, India, United States and Soviet Union) with more irrigated area than Pakistan lose their significant positions, and Pakistan moves to the top.¹² To appreciate the position of West Pakistan, one must realize that almost all the irrigated area lies in this province.

The map (Fig. I) and Table I indicate that the agriculture depends heavily upon irrigation although the relation changes from division to division. It is also obvious that, generally, the divisions with higher irrigation intensity have more total culturable area. This relation however is not applicable to the division of Peshawar (Fig. V-D) which, in spite of lower irrigation intensity, has more total cultivated area. This is because higher precipitation and lower temperatures (Fig. II) make it possible to cultivate without irrigation. So the main obstacle in the way of extending agriculture seems to be the deficiency of water or the absence of irrigation facilities. Irrigation tends to increase the total cultivated area in another way as well; with the increase in irrigated area the water-table in the land lying adjacent to the irrigated fields rises, and it becomes possible to grow certain crops without irrigation. In such areas, installation of wells also becomes easy and cheap.¹³

¹²Gulhati, op. cit., pp. xi-xiii.

¹³P. W. Paustian, Canal Irrigation in the Punjab (New York: Columbia University Press, 1930), p. 78.

Fig. I



★ The circles represent total cultivable area

TABLE I
IRRIGATION AND LAND USE IN WEST PAKISTAN

Division	Total area (sq. miles)	Culturable area (acres)			Total
		Cultivated with irrigation	Cultivated without irrigation	Culturable waste	
Peshawar	28,153	664,142	1,114,641	245,349	2,024,132
Dera Ismail - Khan	11,130	328,702	745,484	1,031,538	2,175,724
Rawalpindi	11,206	659,485	2,837,336	492,258	3,989,109
Sargodha	17,095	4,324,166	2,179,150	923,584	7,226,900
Lahore	8,907	2,815,592	956,496	399,457	4,171,545
Multan	24,826	5,928,864	625,770	1,228,664	7,783,300
Bahawalpur	17,508	2,758,201	268,695	280,942	3,307,838
Khairpur	20,293	3,080,387	175,440	484,089	3,739,926
Hyderabad	36,821	3,075,429	1,448,396	1,110,658	5,634,483
Quetta	53,115	775,638	686,057	308,942	1,770,627
Kalat	72,944	829,582	694,774	420,236	1,904,592
Karachi	8,405	28,634	268,468	116,854	413,956
Total	310,403	25,268,831	11,990,707	7,092,571	44,342,132

Source: 1960 Pakistan Census of Agriculture West Pakistan (Karachi: Agricultural Census Organization Ministry of Agriculture and Works. Government of Pakistan, 1964), I, pp. 112-121, 152-160. S. H. Steinberg (ed.), The Statesman's Year-Book 1968-69 (New York: St. Martin's Press, 1968), p. 432.

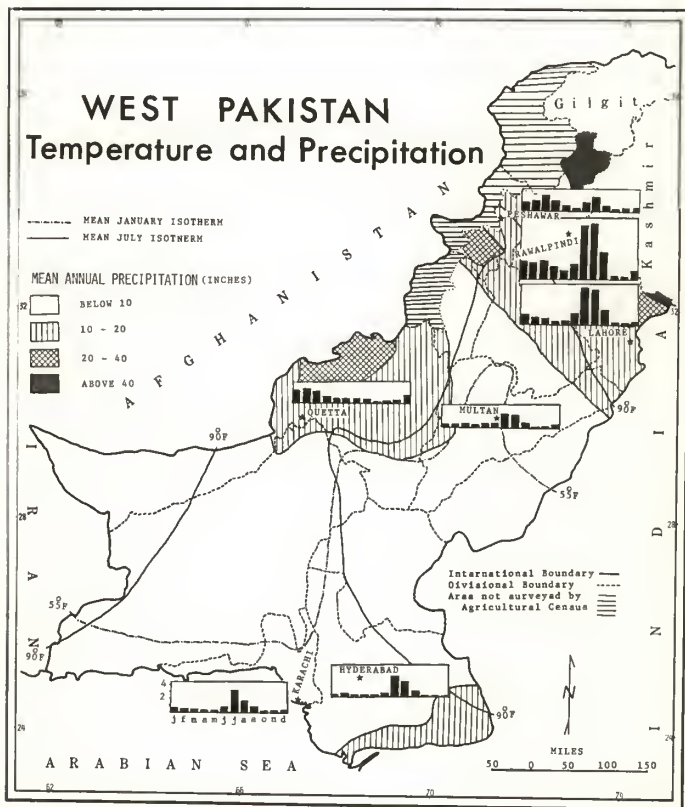
Need for Irrigation

Because agriculture is so valuable, the factors that influence it deserve consideration. In West Pakistan no other single factor dominates agriculture so much as irrigation. Impressed by this, Darling said, "So valuable in fact is water that property in it arose before property in land."¹⁴ The map (Fig. II) should help to explain why irrigation is so important.

In general, the precipitation in West Pakistan is not only very low but its regime is uneven too and it is extremely erratic. Insofar as the total rainfall is concerned, the small area in the extreme north should be taken as an exception. Similarly, the distribution is not so uneven in the mountains and plateaus in the west, even though they have low annual precipitation. Perhaps that is why agriculture in the north and west is comparatively less dependent upon irrigation than the rest of the province. However, under the prevailing climatic conditions, agriculture without irrigation is precarious throughout. Even the areas with 25-35 inches of rainfall are considered worse than the arid part of West Pakistan, because in such marginal regions agriculture is balanced on a knife edge.

Variability is a highly important characteristic of rainfall and is one of the most significant factors influencing agriculture. In one study, variability between 1890 and 1923 over most of present West

¹⁴Sir Malcolm Darling, The Punjab Peasant in Prosperity and Debt (London: Oxford University Press, 1947), p. 93.



Pakistan was found to be over thirty per cent.¹⁵ According to Tayyeb, for West Pakistan as a whole it is about 60-65 per cent.¹⁶ Although he did not mention it he probably meant annual variability. To appreciate its role one should realize that where the variability exceeds twenty per cent and rainfall is less than twelve inches, agriculture cannot be carried on without irrigation.¹⁷ With precipitation dependability so low, agriculture operates under great risks even if the average annual rainfall exceeds the minimum. In some areas, high temperatures coupled with low rainfall result in a relative humidity as low as one per cent.¹⁸ These conditions suggest that in most of West Pakistan irrigation is indispensable for agriculture.

Natural Endowment

Natural conditions such as gentle slope, accessible water, long growing season, and fertile soils are definite attractions for irrigation projects. It was probably under such conditions that prehistoric groups of people started to change the face of the earth by providing water for irrigation in certain river valleys. No doubt today irrigation is not

¹⁵ A. V. Williamson and K. G. T. Clark, "Variability of Rainfall of India," Quarterly Journal of the Royal Meteorological Society, LVII (January, 1931), 45.

¹⁶ A. Tayyeb, Pakistan: A Political Geography (London: Oxford University Press, 1966), p. 128.

¹⁷ A. V. Williamson, "Irrigation in the Indo-Gangetic Plains," The Geographical Journal, LXV (February, 1925), 143.

¹⁸ O. H. K. Spate, India and Pakistan: A General and Regional Geography (London: Methuen and Co., 1957), p. 57.

limited to the areas having the above conditions, but still such conditions provide a definite incentive for irrigation.

In West Pakistan, the fertile plains crossed by great rivers are among the major natural resources of the earth. They are a major physical asset of the world's fifth largest country.¹⁹ The Indus River System, with a mean annual flow of 169 million acre feet (more than three times as large as the Nile, and about ten times as large as the Colorado River), appeared so big to the Aryans that they took it as an ocean and named it "Sindhu" meaning ocean.²⁰ The rivers of the Indus system are fairly evenly spaced (Fig. III) and the pattern is ideally suited for irrigation. Below the rim stations these sediment laden streams usually flow in beds higher than the level of their flood plains.²¹ River regime is extremely irregular and highly seasonal in character. The runoff is characterized by the absence of any pronounced duration of mean flow. In the period 1921 to 1946, the average minimum flow of all the rivers was 26.7 million acre feet, and the average maximum was 141.7 million acre feet. It is not unusual to find the normal summer discharge one hundred times the winter minimum.²² Above all, the river regimes do not fit in with the

¹⁹The White House Department of Interior Panel on Waterlogging and Salinity in West Pakistan, Report on Land and Water Development in the Indus Basin (Washington: U.S. Government Printing Office, 1964), p. 1.

²⁰Aloys A. Michel, The Indus River: A Study of the Effects of Partition (Yale University Press, London and New Haven, 1967), p. 42; and R. A. Malik, "Irrigation Development and Land Occupance in the Upper Indus Basin," (Unpublished Doctoral Dissertation, Indiana University, Bloomington, 1963), p. 18.

²¹Michel, op. cit., p. 46.

²²Malik, op. cit., pp. 19-21.

cropping seasons. During the dry season water discharged from rivers is very low and so the water supplies during the rabi season are always short. On the other hand during two to three months of summer monsoons, rivers carry a large surplus over and above the agricultural needs.

Besides surface water resources, ground water suitable for irrigation can also be exploited. Estimates indicate a ground water reservoir of nineteen hundred million acre feet of fresh water, which is more than ten times the average annual discharge of all the Indus Basin Rivers. This reservoir can yield about sixteen million acre feet per year.²³

As a whole geographical conditions in the study area are such that nature itself would have acted as a motivating force, since in times of abnormal floods more land would naturally be watered and fertilized, suggesting to the riverine population the idea of "catching the flood water for irrigation purposes."²⁴ Considering the prevailing conditions, it appears that West Pakistan must continue to increase its irrigated land in order to capitalize on its agricultural advantages.

Beginning of Irrigation

A study of the environment in West Pakistan indicates that man and agriculture in this area must have been closely related to the development process of irrigation. In this region irrigation has been an areal

²³ "Formulation of a Planning Program for Water Resources Development in West Pakistan," Proceedings of the Fifth Regional Conference on Water Resources Development in Asia and the Far East (Water Resources Series No. 23. New York: U. N. Economic Commission for Asia and the Far East, 1963), p. 164.

²⁴ Ibid., p. 36.

expression which indicates the perpetual interaction between man and his milieu. In fact, the irrigation-agriculture complex is so much inter-related that it is difficult to determine which is cause and which is effect. In the course of history man has developed irrigation technology and humanized the natural environment by remodeling it into the cultural environment.

In spite of occasional efforts, it has not been ascertained when irrigation began in the subcontinent. However, recent archaeological findings and historical literature indicate that advanced civilizations supported by complex agriculture and irrigation systems existed over many parts of the present West Pakistan. It has been found that the people of Harappa and Mohenjo-daro were builders of irrigation complexes much like dams and tanks. The village settlements of Baluchistan and Sind, along with a large number of stone-built dams for irrigation, are even older than the Indus Civilization.²⁵ This shows that irrigation might have begun much earlier than 3000 B.C., so that about that time it supported advanced cultures and was widely practiced in the northwestern subcontinent. There is no evidence as to what happened to this well-organized civilization, however, Bryson guesses that the Harappans misused their land and turned it into a desert. He further argues that it took nature a thousand years to heal the scars so that the people could move in and use the land again.²⁶

²⁵A. O. Whyte, "Evolution of Land Use in Southwest Asia," A History of Land Use in Arid Regions, ed. L. D. Stamp, XVII of Arid Zone Research (Paris: UNESCO, 1961), p. 104.

²⁶Reid Bryson, "Is Man Changing the Climate of Earth," Saturday Review (April 1, 1967), 53.

The credit for providing the earliest direct information about the Indus Basin goes to the Greek scholars who accompanied Alexander the Great in his invasion of India in 327 B.C. Aristoboulos, who accompanied Alexander, gives an interesting account of life in this region and mentions the existence of irrigation in various connections.²⁷ After the Greeks, the fertile Indus Plain attracted many invaders including the Persians, Arabs, Tartars, Moghuls and finally the British.

During and after the tenth century many Arab geographers visited the Indus Basin and gave considerable information about the geography of this region. Abu Ashak, one of the distinguished Arab geographers, has given specific information about the system of irrigation that existed in the Indus Basin during the tenth century. In his Book of Climates, he frequently refers to the irrigation system associated with the rivers.²⁸ The writings of all early scholars show that inundation canals found in this region were similar to those of the irrigation system of early Egypt. It may also be supposed that some sort of public organization had been established for the construction and maintenance of canals which were too big and complex to be managed by individuals.

The period of the Moghuls is probably the most important as far as the change in prehistoric irrigation system is concerned. Before coming to the Indus Basin, the Moghuls had irrigation experience in Central Asia. They realized that a stable government and internal

²⁷Malik, op. cit., p. 32.

²⁸Ibid., p. 33.

peace were prerequisites for an efficient irrigation system. The peace and order established by the Moghuls were followed by the development of an organized irrigation system. Provincial governors were ordered by the King to pay special attention to irrigation works.²⁹ It was under the Moghuls that water for the first time reached doabs higher than river beds. The first canal that reached an upland was constructed in A.D. 1315. The same canal in the reign of Akbar the Great was renovated and remodeled to irrigate more areas in Hisar District (India) of former Punjab. Later a Moghul engineer constructed another branch from this canal to provide water for the irrigation of the Imperial Gardens around Delhi.³⁰ Credit for introducing perennial irrigation to the Indus Basin also goes to the Moghuls. The Huslee Canal in the reign of Shah Jehan, was the first perennial canal constructed in this region. This canal had been taken from the Ravi River at Madhapur (India) and was apparently controlled by a fairly efficient weir which insured a permanent water supply even when the British took control of this region.³¹ The present Upper Bari Doab Canal (Fig. III) was constructed in 1859 on a Moghul alignment of the Huslee Canal. Considering the time of their construction, these irrigation works were great engineering complexes.

Irrigation in the British Period

To appreciate the British contribution to the irrigation system

²⁹Whyte, op. cit., p. 110.

³⁰H. K. Trevaskis, The Land of the Five Rivers (Oxford: Oxford University Press, 1928), p. 131.

³¹Paustian, op. cit., p. 26.

of West Pakistan, it must be noted that, unlike the previous invaders, the British had virtually no experience in this field. There was no irrigation in Britain itself or North America, South Africa and Australia, colonized by the British prior to 1849.³² However, the British administrators and engineers brought with them the technology of the Industrial Revolution. This technology, already applied in the construction of navigation canals in England, produced in a different environment the "world's largest contiguous irrigation system" and made the Upper Indus Basin the "granary of the subcontinent."³³ The rate at which irrigation development took place can be appreciated from the fact that between 1854 and 1937 nearly thirty-two million acres were added through irrigation to the cultivated area in British India. In the single province of Punjab, irrigated area increased from 1,025,156 acres in 1867 to 12,800,000 acres in 1938.³⁴ To understand how this development took place, a review of the political and economic conditions of the region is necessary.

British penetration of the Indus Basin began in 1809 but it took time to bring about political stability, which according to Trevaskis, is a prerequisite to the complicated organization necessary for a great irrigation system.³⁵ The region, situated on the highway of every

³² Michel, op. cit., p. 50.

³³ Spate, op. cit., p. 467.

³⁴ Hamid Alvi, "The Canal Irrigation System of West Pakistan," Pakistan Quarterly (Winter, 1967), pp. 47-55.

³⁵ Trevaskis, op. cit., p. 75.

invader from Central Asia, was conspicuously unstable. However, political stability was brought to the extent that at no previous time in history was such an area subject to the political control of a power that could bring to bear the advanced technology and financial resources necessary to bring such a large contiguous area under the command of canals. The British were impressed by the irrigation potentialities of the Indus Basin. Along with a lavish quantity of water that could be tapped without reservoir storage for gravity distribution, the people were deeply sensible to the values of irrigation works and had the ability not only to construct irrigation works but also to distribute a regular supply of water.³⁶

Soon after a preliminary investigation into existing conditions, the British reached the conclusion that if the Indian economy was to complement the English commercial policy, it would be necessary to increase agricultural production so that large amounts of agricultural raw material would be provided for the British factories.³⁷ Another of their motives might have been to eliminate the famines which had become a regular disaster in Punjab since 1783.

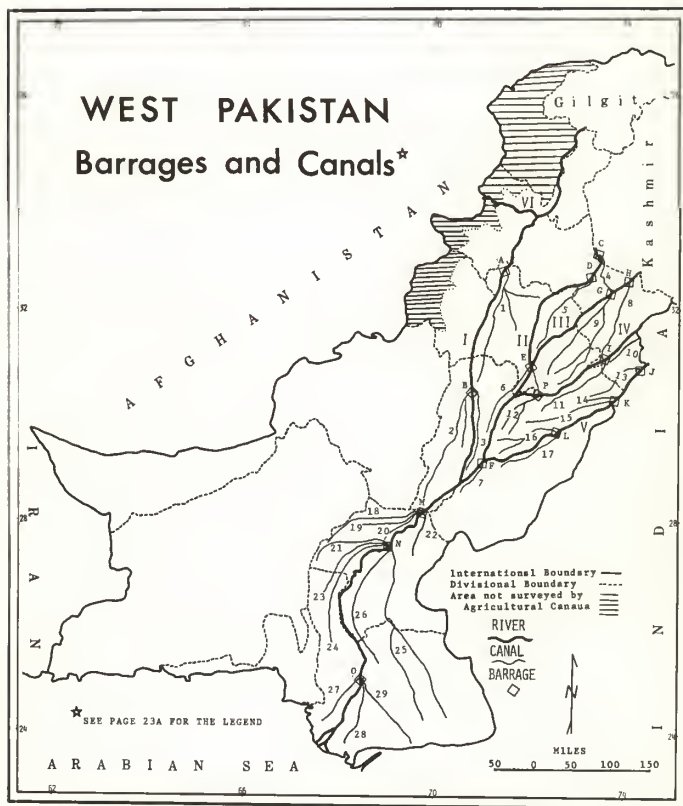
Under these conditions and for such motives, the British initiated irrigation in Punjab, and it was quite natural that the first schemes should concentrate on that part of the territory known as Bari Doab.³⁸

³⁶Paustian, op. cit., p. 21.

³⁷Malik, op. cit., p. 65.

³⁸Ibid., p. 27.

The Huslee Canal was operating in the northern part of Bari Doab. In 1854-60, the net revenue from this canal amounted to Rs. 67,507. It was anticipated that the canal, when reconstructed along modern lines, could considerably increase the revenue and agricultural production. So the canal was reconstructed in 1859 and named the Upper Bari Doab (Fig. III). This project proved to be so economical that, at the end of 1878, the total income received by the government had exceeded the construction expenses as well as the interest on the capital. The success of this first project encouraged the British Government as well as private investors. When the British Government started accepting private investment, the investors in England were prompt in response. The first canal to be constructed in the Indus Basin by funds raised in the London market was the Sirhind Canal (India). Shortly after this the Sidhna, Lower Sohag, and Para Canals (Fig. III) were constructed. The Sidhna and Lower Sohag canals in Multan Division were the first colony canals. These were constructed in an uninhabited area and resulted in an agricultural pattern different from the areas already thickly populated. This point will be elaborated later. However, the canals constructed in areas already under high population density did not bring about much change in the traditional agricultural and crop patterns. After a large part of the Bari Doab had been irrigated, the next area to come under irrigation was Rechna Doab. One of the most important canals constructed in this area was the Lower Chenab Canal (Fig. III). This was constructed in 1892, and with it great canal colonies were created in Lahore and Sargodha divisions. The Lower Jhelum Canal, which irrigated



Source: A Compendium of Major International Rivers in the ECAFE Region: Water Resources Series No 22 (New York: United Nations ECAFE, 1969, p.56.

LEGEND FOR FIGURE III

BARRAGES

A	JINNAH
B	TAUNSA
C	MANGLA
D	RASUL
E	TRIMMU
F	PUNJNAD
G	KHANKI
H	MARALA
I	BALLOKI
J	FAROZPUR
K	SULAMANKI
L	ISLAM
M	GUDU
N	SUKKUR
O	GHULAM MOHAMMAD
P	SIDHNAI

RIVERS

I	INDUS
II	JHELUM
III	CHENAB
IV	RAVI
V	SUTLEJ
VI	KABUL

CANALS

1	THAL
2	D.G.KHAN
3	MUZAFFARGARH
4	UPPER JHELUM
5	LOWER JHELUM
6	RANGPUR
7	PUNJNAD
8	UPPER CHENAB
9	LOWER CHENAB
10	UPPER BARI DOAB
11	LOWER BARI DOAB
12	SIDHNAI
13	DIPALPUR
14	LOWER SOHAG
15	PAKPATTAN
16	MAILSI
17	BAHAWAL
18	PAT FEEDER KASHMOR
19	DESERT
20	BAGARI
21	NORTH WESTERN
22	GHOTKI
23	RICE
24	DADU
25	EAST NARA
26	ROHRI
27	KOTRI
28	PINYARI
29	FULELI

areas in Rawalpindi and Sargodha divisions, was constructed in 1901. This canal created another major colony in Sargodha division. The magnitude of the work can be appreciated when it is noted that in 1901 each of the Punjab rivers, except the Beas (India), had been tapped, and a network of canals supported by weirs and barrages (Fig. III) was irrigating 4.6 million acres in Punjab.³⁹ For the first time it appeared as if the problem had been solved and objectives achieved.

Incidentally, a severe famine occurred about 1901 which resulted in the creation of the Indian Irrigation Commission. The purpose of this commission was to explore the possibilities for more irrigation projects as protection against famine.⁴⁰ The commission considered various possibilities and came up with the conclusion that the Punjab was still the best place for irrigation extension. So, for further irrigation extension, the northern part of Multan Division was recommended; the problem was, however, to find a water source. The only river which could irrigate this area was the Ravi, but most of its water was already being used through the Upper Bari Doab Canal. There was surplus water in Jhelum River, two hundred miles towards the north, but this would have to be brought across the rivers (Chenab and Ravi) flowing in between.⁴¹ The solution to this problem came, according to Andrus and Mohammed, "in one of these flashes of creative genius that, in other branches

³⁹Michel, op. cit., p. 82.

⁴⁰Ibid.

⁴¹J. Russell Andrus and Azizali Mohammed, The Economy of Pakistan (Stanford University Press, California, 1958), p. 84.

might have been recognized as a contribution to the art." The idea was simply to transfer the water from western rivers to eastern rivers. Under this plan, the Triple Canal Project was promptly undertaken in 1905. A canal called the Upper Jhelum Canal was taken from the river Jhelum at Mangla. Its main purpose was to deliver water into the Chenab just above the existing Khanki Barrage (Fig. III), but on the way it also irrigated about 345,000 acres of land in the Upper Chej Doab. With the transfer of water from Jhelum to Chenab, it became possible to construct the Upper Chenab Canal. Besides irrigating 65,000 acres in Upper Rechna Doab, this canal delivered enough water to Ravi for irrigation of the Lower Bari Doab through a canal of the same name. This canal has the largest capacity among the canals of the Indus Basin. It crossed Ravi at Baloki by means of a barrage designed as a level crossing, which transferred the water to the Lower Bari Doab Canal. Lower Bari Doab Canal irrigated about 1,494,000 acres. The project brought under irrigation almost all of the Bari Doab. But for the technology probably developed for the Panama Canal, such an irrigation project would have been impossible. Among the headworks constructed for this project, the one called Baloki was different from all the headworks constructed before in the subcontinent because it was the first barrage with proper gates constructed to adjust the level of water.⁴² Irrigation progress was slowed down during the First World War, yet by 1937-38 over thirteen million acres had been irrigated in Punjab. A major portion of the irrigated

⁴²Michel, *op. cit.*, p. 91.

area was located in the canal colony districts of Sargodha and Multan divisions.⁴³

The development of irrigation, insofar as its impact upon agriculture is concerned, is different in the Lower Indus Basin. Although a number of canals were constructed after 1851, all were inundation canals. Michel has described very well the physical, political and economic factors which had discouraged government authorities from developing perennial irrigation in this region. It was only when the resources of the Upper Indus Basin were exhausted that the Lower Indus Basin came under consideration. Another important reason for the beginning of perennial irrigation in this area was that due to withdrawal of an enormous quantity of water in the Upper Indus Basin, the supply of water in inundation canals of Khairpur and Hyderabad divisions had become very unreliable and thus affected greatly the existing agricultural structure of the region which was adapted to seasonal water supply.⁴⁴ Decreasing agricultural production and the possibility of the existing inundation canals becoming completely inoperative resulted in an ambitious program of constructing barrages directly across the Indus River in the Lower Indus Basin.

The first barrage built was the Sukkur Barrage (Fig. III) constructed in Khairpur division. It was completed in 1932 with a capacity to provide perennial irrigation for 5.4 million acres. Its capacity has

⁴³Andrus and Mohammed, *op. cit.*, p. 85.

⁴⁴S. Z. Ahsan, "Guddu Barrage Project: A Geographical Analysis," *Geographia*, IV (1965), p. 47.

been further increased to irrigate 7.5 million acres (some perennial and some nonperennial). Sukkur Barrage is considered to be the largest in the world.⁴⁵

The British Government did not pay notable attention to the area now under the divisions of Peshawar, Dera Ismail Khan, Quetta and Kalat, apparently because of the deficiency of water resources, the political instability and the absence of an economic incentive. Certain small irrigation projects were undertaken but incidentally in the area not surveyed by the Agricultural Census Organization and thus beyond the scope of this study.

In this brief description of irrigation development in West Pakistan before and during the British period it is very striking that in the tremendous irrigation development, almost as large as the entire development in seventeen western states of the United States, not a single storage dam was constructed, and all the schemes were based on the natural flow of the rivers. Under the seasonal regime of the Indus River System, as discussed earlier, irrigation without storage reservoirs is clearly treacherous. Various reasons can be given for not constructing reservoirs. It is said that the rivers of West Pakistan are generally very high in their silt content. They are young in age and pass through sedimentary rocks with little vegetation cover and so are

⁴⁵Gulhati, op. cit., p. 77.

high in silt content and not suitable for dams.⁴⁶ Another reason given by the Indian Irrigation Commission is that the dams would be prohibitively expensive.⁴⁷ Whatever the reason, the point to be noted is that water for irrigation in the dry season (winter) has not been available in most of the area commanded by weirs and barrages. For example, perennial irrigation from the Sutlej Valley Canals was possible only on 2,169,000 acres out of the total irrigated area of 4,484,000 acres.⁴⁸ The difference in perennial and nonperennial irrigation, as will be seen later, has significant consequences in crop patterns. It will be seen that the only possibility of agriculture under nonperennial irrigation is to adopt a cropping system suited to the regime of river flow.

Irrigation Since Partition

Partition in many respects was a turning point in the development of irrigation in West Pakistan. The direction taken by irrigation after 1947 was an outcome of changed political conditions as well as technological innovations in the area. For the first time in its history, the region got rid of the feudal system and came under a democratic government which, obviously, had different motives. The achievement of the changed objectives, as will be seen, became possible only with the help

⁴⁶R. A. Kazi, "Factors Affecting the Selection of a Dam Site: Selection of the First Storage Dam on Indus." Proceedings of the Regional Symposium on Dams and Reservoirs: Flood Control Series No. 21, (U.N. Economic Commission for Asia and the Far East, 1962), p. 191.

⁴⁷Michel, op. cit., p. 84.

⁴⁸Ibid., p. 112.

of technology in irrigation engineering developed mainly in the United States and successfully applied in the Hoover Dam and the Missouri River Basin.⁴⁹ Certain problems and handicaps created with partition also played a significant role in the development of irrigation after 1947.

Due to the dominant economic motives of the colonial government, as noted earlier, most economical and easily exploitable water resources had been exhausted before the partition. This to some extent was realized even in the beginning of the twentieth century by the Indian Irrigation Commission and was confirmed later in the drafting of the Five Year Plans. According to the planners, very limited irrigation possibilities existed without constructing storage dams or exploiting underground water resources.⁵⁰ Another handicap inherited from pre-partition days was overassessment of irrigated land with high and unfair taxation. This operated as a bar against the extension of irrigation by indigenous private capital.⁵¹ The desire to extend available water over a maximum area resulted in very low application of water per unit area. In canal-irrigated areas of West Pakistan, the average quantity of water applied was found to be between seventeen and twenty-two inches, while for satisfactory agricultural operations under the climatic conditions

⁴⁹ Edward A. Ackerman and G. O. G. Löf, Technology in American Water Resources Development (Washington: Resources for the Future, 1959), pp. 227-29; Michel, op. cit., p. 445.

⁵⁰ Andrus and Mohammed, op. cit., p. 89.

⁵¹ Trevaskis, op. cit., p. 88.

of West Pakistan, four feet of water per year must be available.⁵² In the British period rapid extension of irrigation, with insufficient water and the absence of drainage, introduced the challenging problem of salinity and waterlogging, by which one hundred thousand acres of irrigated land of West Pakistan are going out of cultivation every year.⁵³

Another problem created with the partition appeared when the boundary between West Pakistan and India was drawn across an integrated irrigation system. The sources of most of the rivers and the heads of some of the canals irrigating areas in West Pakistan went to India. The implications of this situation are beyond the scope of this study and have been discussed adequately in certain references in the bibliography. However, for the purpose of this study it should be noted that, soon after partition, more than one million acres of fertile irrigated area in the Upper Indus Basin went out of cultivation due to the stoppage of water in canals with headworks in India. The next problem, a legacy of partition, was the immigration of refugees. By 1953, six million seven hundred thousand refugees had entered West Pakistan, and the inflow continued long after that.⁵⁴ Insofar as its impact upon irrigation-agriculture

⁵²A. V. Karpov and Ross Nebolsine, Indus Valley: Key to West Pakistan's Future (Lahore: Water and Power Development Organization Printing Press, 1963), p. 23; and The White House...Department of Interior, op. cit., p. 97.

⁵³American Geographical Society, "Pakistan," Focus, XVII, No. 5 (January, 1967).

⁵⁴Pakistan Publications; Karachi, Sixth Year - Pakistan 1953, p. 198.

is concerned, it is important to note that most of these people were agriculturists.⁵⁵

These were the conditions which necessitated, stimulated and directed the process of irrigation in West Pakistan after the British left this region. New projects were undertaken and those already under construction were completed rapidly. Between 1947 and 1960 an area of 6,145,200 acres was brought under irrigation. This included 2,814,000 acres of land already irrigated apparently inadequately. In addition, seven hundred forty thousand acres were reclaimed by constructing drainage channels and by drilling tubewells.⁵⁶ The following projects deserve a brief description.

Thal project. Thal is the area between the rivers Indus and Jhelum. It was an empty desert with water available for irrigation in the Indus River in the northwest. A barrage called Jinnah Barrage was constructed at Kalabagh (Fig. III) in 1955. This provided irrigation to about two million acres. Along with the construction of canals went the settlement of refugees. Until 1956, about 43,712 families, consisting mainly of refugees, had been settled in 830 new villages constructed in Sargodha and Multan divisions. Impressed by this project, Rushbrook remarked, "But never, I think, have we...seen more dramatic example of the conquest of natural obstacles by human energy."⁵⁷

⁵⁵L. F. Rushbrook Williams, The State of Pakistan (London: Faber and Faber, 1966), p. 164.

⁵⁶Andrus and Mohammed, op. cit., pp. 80-81.

⁵⁷Williams, op. cit., p. 165.

Chulam Mohammad barrage. Partly necessitated by the need to find more land on which to settle the refugees, this project was completed in 1961. It enabled a network of existing inundation canals to be changed into perennial ones. The project commanded a total area of 2,800,000 acres, of which 1,700,000 acres were irrigated for the first time.⁵⁸

Taunsa barrage. Completed in 1957, it provided perennial irrigation to more than 1,500,000 acres which were served before by inundation canals. Besides, it irrigated an additional three-quarters of a million acres mainly in Multan Division.⁵⁹

Gudu barrage. Work on this project started in 1958. This project has been carried on in phases. Upon its completion in 1976, it will command 3,200,000 acres in Khairpur and Kalat divisions. Up to 1960, however, it was expected to improve irrigation on 1,600,000 acres and irrigate 1,300,000 acres of virgin land to be brought under cultivation.

Besides these projects, various link canals were constructed between Chenab-Ravi and Ravi-Sutlej to compensate for the water shortage in the Sutlej valley area. Some irrigation was also done in the previously neglected areas of Peshawar, Dera Ismail Khan, Quetta and Kalat divisions.⁶⁰ During this period, exploitation of underground water resources remained insignificant. In the First Five Year Plan (1955-60), provisions were made for fifteen hundred tubewells, but only one thousand

⁵⁸Twenty Years of Pakistan (Rawalpindi: Pakistan Publications, 1967), p. 222.

⁵⁹Ibid., p. 223; and Andrus and Mohammad, op. cit., p. 87.

⁶⁰The Second Five Year Plan 1960-1965 (Government of Pakistan Planning Commission, 1960), pp. 200-201.

were drilled and even these were not put into operation due to the deficiency of electric power. Another characteristic of irrigation until 1960 was the absence of private investment. Even during the First Five Year Plan no private investment was included in the outline of the plan for irrigation.

The development of irrigation since the latest (1960) census of agriculture is not essential to the purpose of this study. However, a review of irrigation projects since 1960 might give an idea of the future trends in agriculture. The important features of irrigation development after 1960 are: encouragement of private investment, emphasis on reclamation of deteriorated land, development of hydro-electricity through multipurpose projects, and implementation of the Indus Basin Treaty.

Private investment in irrigation in the Second Five Year Plan (1960-65) was 60 million rupees, and in the Third Plan it increased to 650 million rupees. This investment went mainly to the improvement of the existing distribution system and the installation of tubewells, with a view to stabilizing the supply of water. The emphasis on multipurpose projects is obvious from the fact that, in the Second Five Year Plan, 790,500,000 rupees were spent on multipurpose projects as compared to 437 million rupees on purely irrigation projects. Genuine importance was given to the areas outside the Indus Basin, and small multipurpose and irrigation projects were emphasized. A program was made to investigate one hundred fifty sites for the construction of small dams; eighty-five of such dams would be constructed by 1970. Due importance has been

given to the exploitation of underground water resources through private investment. Up to 1965, thirty thousand private tubewells were successfully installed.⁶¹ The objective of these programs has been, obviously, to increase the intensity of irrigation and to develop an optimum crop pattern rather than to spread the water thinly over vast areas. The problems of waterlogging and salinity have been effectively undertaken. A gigantic plan was made to reclaim the waterlogged and saline area. According to this plan, some thirty-one thousand five hundred tubewells will be constructed. The total cost of these projects is more than thirty-four hundred million rupees.⁶² Besides, a very comprehensive study done by a scientific commission appointed by the President of the United States was completed and submitted to the Government of Pakistan for action.⁶³

Another and perhaps the most important project undertaken in the period under consideration is the magnificent Indus Basin Treaty.⁶⁴ Impressed by the magnitude of the project, Hodges said, "Pakistan, a young yet venerable nation, is about to commence the design and construction of the greatest irrigation project yet undertaken by man,

⁶¹The Third Five Year Plan 1965-1970 (Government of Pakistan, 1965), p. 291.

⁶²West Pakistan Water and Power Development Authority, Program for Waterlogging and Salinity Control in the Irrigated Areas of West Pakistan (Lahore: West Pakistan WAPDA, 1961), p. iv.

⁶³The White House Department of Interior Panel on Waterlogging and Salinity in West Pakistan, op. cit.

⁶⁴R. E. Black, "The Indus: A Moral for Nations," The New York Times Magazine (December 11, 1960).

while at the same time, continuing to operate uninterrupted the world's most extensive irrigation system.⁶⁵ The progress of work on this project has been according to schedule. One of the dams constructed under the Indus Basin Treaty was completed in 1967. The London Times described it as the world's largest earthfilled dam, 2.5 times larger than the Aswan Dam. In the words of L. P. Johnson, "the dam at Mangla fulfills man's oldest and most notable dream: to harness nature for the lasting benefit of all."⁶⁶ The giant Torbela Dam, another dam of the Indus Basin Treaty, three times the size of the Aswan High Dam was also started in 1968. All these projects, when completed, will determine the future course of West Pakistan's agriculture. The following chapters, dealing with the irrigation-agriculture complex before 1960, may be helpful in forecasting what that course might be.

⁶⁵R. C. Hodges, "Indus Water for Pakistan," Canadian Geographical Journal, LXI (September, 1960), p. 96.

⁶⁶Government of Pakistan, Rawalpindi, Pakistan News Digest, December 1, 1967.

CHAPTER III

TYPES OF IRRIGATION

Various types of irrigation are practised in West Pakistan. The types are dissimilar because of the sources of water and the techniques applied to acquire the water for irrigation. A discussion of irrigation types in West Pakistan is important because, on the one hand, they are the result of interaction between physical, economic, and cultural factors; and on the other hand, they have influenced the agricultural pattern in the Province. In fact, it will be observed later that the relation between types of irrigation and certain other agricultural elements in most parts of West Pakistan is so close that it becomes difficult to decide which is the cause and which is the effect. Before further discussion it should be noted that, irrespective of the source or technique, the important aspects of irrigation water are: average quantity, regularity, reliability from year to year, timing in relation to growth cycle of crops, and physical and chemical properties. The following analysis of irrigation types should help in an understanding of their spatial distribution and the extent to which they have influenced the agricultural pattern in West Pakistan.

Canal Irrigation

Considering the total irrigated area as well as the area under different types of irrigation, canal irrigation is the most important. Before an explanation of this point, it is important to note that there are three types of canals: perennial, nonperennial and inundation canals.

Perennial canals are normally supported at their heads by a weir or a barrage and carry irrigation water throughout the year, although not necessarily the same quantity of water. As a weir or a barrage only diverts the water flow and does not store it, under the river flow condition in West Pakistan it is natural that many of the canals supported by weirs or barrages should become dry in the low water season and that the quantity of water in others should be reduced considerably. So actually, perennial irrigation is available only for a part of the area commanded by such a canal system. This can be further substantiated by the fact that in Sargodha and Hyderabad (with an extensive network of canals), only eight and eighteen per cent of the cultivated area respectively is double cropped. The reason for producing only one crop per year from most of the area seems to be the deficiency of water.

Nonperennial canals run only during the season when rivers have enough water (summer, in this case). Such canals could be weir-supported or even without weir and are thus widely found throughout the province.

Inundation canals are necessarily without any weir or barrage and work only during the short summer rainy season when rivers are in flood. Such canals, though found over most of the study area, are more common in the lower part of the Upper Indus Easin and in the Lower Indus Basin where the volume of water increases as the tributaries join the main river.⁶⁷ Under exceptional conditions an inundation canal might work throughout

⁶⁷ R. B. Buckley, Irrigation Works in India and Egypt (London: E. and F. N. Spon, 1893), p. 18; and Malik, op. cit., pp. 37-38.

the year. This had been the case in the Lower Indus Basin before the present network of canals, weirs, and barrages was spread in the Upper Indus Basin. It was noted in the previous chapter that in the beginning of the present century rapid irrigation development in the Upper Indus Basin reduced the water available for the inundation canals of the Lower Indus Basin, which became more precarious. As a result it was realized that barrages would be necessary in the Lower Indus Basin.

One of the important points to be noted about the area served by nonperennial canals is the duration for which water is available. In these canals, supplies run from the 15th of April to the 15th of October.⁶⁸ The same duration can also be loosely applied to the areas commanded by inundation canals. The duration of water supply in canals has significant consequences and greatly influences the crop pattern. It will be noted later that certain crops grown in West Pakistan are such that they need water before April 15 and after October 15.

As regards the importance of canal irrigation as a whole, in 1960 the total area irrigated in West Pakistan was 25,268,831 acres; and out of this total, 19,633,978 acres were irrigated by canals. Considering the divisional distribution, Sargodha Division had the maximum canal-irrigated area of 3,945,661 acres. This is about ninety-one per cent of the total irrigated area of this division. The divisional distribution of canal irrigation and its importance as compared with other irrigation

⁶⁸A. G. Asghar, "Distribution System of Irrigation Water in Pakistan," Third Regional Practices Leadership Seminar NEA Region (Lahore: Government of Pakistan and U.S. International Cooperation Administration, 1966), p. 143.

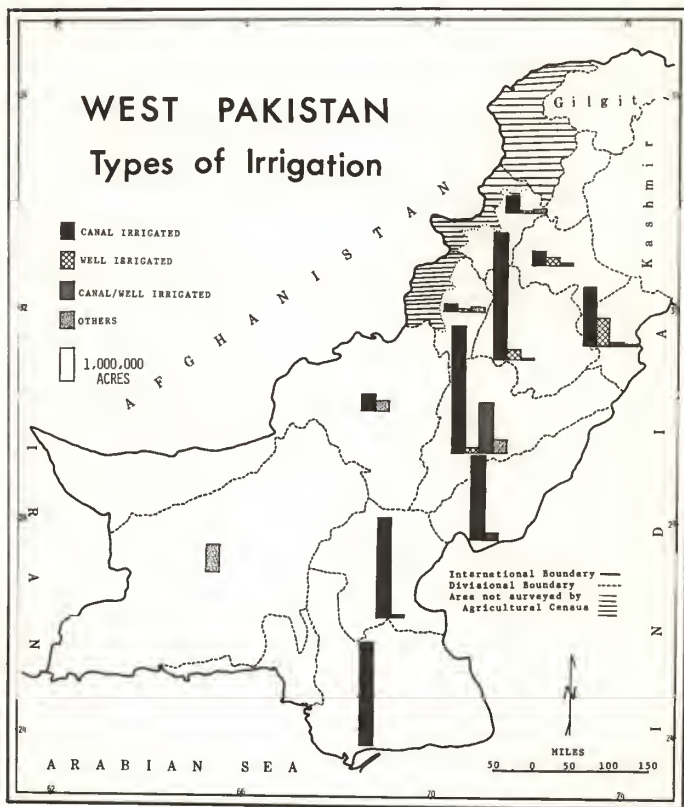
types are shown on the map (Fig. IV). Besides the three individual types of irrigation, the map shows some area designated as canal/well irrigated. Apparently, this area has been irrigated by both canals and wells. It can safely be assumed that this condition exists over the areas under nonperennial or inundation canals, because there should be no need of supplementing with well irrigation when the canals have enough water throughout the year. It has been found that if canal water is available, the farmers prefer to use this because canal water is considered to be superior to well water as far as irrigation is concerned.⁶⁹

It is evident from Fig. IV that throughout the Indus Basin, canal irrigation is dominant. However, there is variation in relative importance. Canal irrigation becomes more and more dominant as one moves from the Northeast to the Southeast. It is relatively less important in the submontane divisions of Peshawar, Rawalpindi, and Lahore. In the division of Rawalpindi canal irrigation counts for only sixty per cent of the total irrigated area. In the extreme southeastern division of Hyderabad, almost one hundred per cent of the total irrigated area is canal-irrigated.

The only three divisions partially outside the Indus Basin are Dera Ismail Khan, Quetta and Kalat. Canal irrigation is less important in these divisions as a whole. The position of Kalat is striking because this is the only division in West Pakistan which did not report any canal irrigation in 1960.

⁶⁹Euckley, op. cit., p. 22.

Fig. IV



For the understanding of irrigation types in West Pakistan, it should be noted (Fig. II) that the submontane divisions receive maximum precipitation, and its regime is also not so uneven. The divisions outside the Indus Basin do not have any sizeable streams or rivers, and precipitation here is evenly distributed as compared to the rest of the province. It will be seen later that the ground water potentialities and the small size of farms stimulated well irrigation and discouraged canal irrigation in the submontane divisions. In the divisions outside the Indus Basin political insignificance, as a result of low population density and absence of economic incentive, has also influenced irrigation practices.⁷⁰ It will also be seen later that due to the absence of incentive for canal irrigation people of these areas had to adopt other methods.

Well Irrigation

According to the area irrigated, well irrigation is the second important type found in West Pakistan. Historically, there were times when well irrigation was more important than it is today, and geographically there are areas where it is still more important than other types. In fact, so much has been written about the canal irrigation in the subcontinent that there is a tendency to think of irrigation only in terms of canals, barrages, and dams. Consequently, it is often a surprise to learn that as late as 1925 over one-half of the acreage under irrigation in British India was nourished by small private works of which the

⁷⁰The Third Five Year Plan 1965-1970, op. cit., map opposite p. 374.

principal is that ancient aid to husbandry, the well.⁷¹ For an understanding of well irrigation in West Pakistan in 1960 and even now, a brief historical review is in order.

It has been found that within the present limits of West Pakistan, shallow wells have been used for irrigation on a limited scale since pre-historic times.⁷² The Rig-Veda, one of the oldest books giving information about India, refers to the production of water by digging, much before 600 B.C. Later, the Moghuls are reported to have dug a succession of wells from Bengal to the Indus.⁷³ The techniques of lifting water from wells have been changing according to the technology available in the region. Buckley has described these techniques very well and has also discussed the impact of technology upon them.⁷⁴

The use of draft animals and the introduction of the Persian wheel were great technological innovations of that time. They made the use of animal power possible and thus considerably increased the height of lift. It is not precisely known when the Persian wheel was introduced, but its name suggests that it probably appeared in the tenth century when the Muslims invaded the subcontinent.⁷⁵

⁷¹Williamson, op. cit., p. 145.

⁷²A. G. Asghar, "Public Awareness and the Educational Problems in Irrigation and Land Use in Pakistan," The Problems of the Arid Zone: Proceedings of the Paris Symposium (Paris: UNESCO, 1966)

⁷³Whyte, op. cit., p. 112.

⁷⁴Buckley, op. cit., pp. 1-24.

⁷⁵Irevaskis, op. cit., p. 75.

The Persian wheel consists of a large drum, over which is placed a rope or iron chain with buckets attached to it at intervals of one or two feet, and whose lower end dips into the water in the well. The drum is then rotated by means of a simple roundabout gear, worked by a pair of bullocks or buffalos, or a camel.

The Persian wheel spread very rapidly in the subcontinent, and today well irrigation is carried out primarily by this method. Until the beginning of the present century well irrigation was much more important than it is today. About A.D. 1900 thirteen million acres were irrigated by this means in British India. At that time seventeen million acres were supplied by canals.⁷⁶ After this, canal irrigation spread so rapidly that in some areas wells were replaced by canals. Ground water engineering could not keep pace with canal water engineering. Consequently, well irrigation became six or seven times more expensive than canal irrigation,⁷⁷ and it has been reduced both in absolute and in comparative importance. In 1960 when more than twenty-five million acres were irrigated in West Pakistan, only about two million acres were purely well-irrigated, while another two million acres were partially irrigated by wells.

As shown on the map (Fig. IV), well irrigation is generally found in the Upper Indus Basin and in Dera Ismail Khan Division in the northwest. Wells are concentrated mostly in the northeastern submontane

⁷⁶Michel, op. cit., p. 449.

⁷⁷Ibid., p. 448; and Spate, op. cit., p. 209.

divisions of Rawalpindi and Lahore. The area where well irrigation supplements canal irrigation is mainly in Multan and Bahawalpure divisions. Within the submontane divisions there is variation in the number of wells and the area irrigated by them. Intensity of well irrigation decreases from the northeast to the southwest of these divisions. Some well-irrigated area is also found in Sargodha Division and is concentrated in the extreme northeast of this division.⁷⁸ Importance of well irrigation in the submontane area can be realized by the fact that in Sialkot District of Lahore Division well-irrigated land in 1960 totaled 369,843 acres as compared to 26,765 acres supplied by canals.

The predominance of well irrigation in the submontane area is due to the high water table, more precipitation and smaller size of holdings. Lying at the foot of the Himalayas, the region has a series of alluvial fans built up by the rivers. Water table is high because percolation and seepage from the hill torrents continuously recharge the underground water.⁷⁹ Precipitation over most of this area is twenty inches or more, but, as noted in the previous chapter, variability is high. Due to the variability there has always been need for an insured water supply during the time of scarcity, especially when the monsoon rains came late or ended prematurely. This condition necessitated irrigation, and a high water table made well irrigation easy and economical. Well irrigation is more suited to the area with comparatively humid conditions, as it is

⁷⁸Malik, op. cit., p. 40.

⁷⁹Spate, op. cit., p. 47.

not a successful economic undertaking under very dry conditions, unless supplemented by canals. Without a considerable quantity of precipitation the area irrigated by a Persian wheel is too small to support a family and a few cattle. This point has also been emphasized by Darling who said that no one would think of sinking a well unless he could depend upon an ample supply of rain to mitigate the toil of his bullocks.⁸⁰

Well irrigation is suitable for small holdings because a well can be constructed through individual enterprises by the owners of small farms. It will be seen in the next chapter that the size of holdings is predominantly small in the submontane area of West Pakistan. Another factor which might have helped the construction of wells is the high population density and the presence of many urban areas. High population density provides cheap labor and nearby urban centers provide a ready market for high-value crops such as fruits and vegetables. It was acknowledged earlier that well irrigation is very costly, and so to compensate for high cost the farmers must grow high-value crops. Since such crops are perishable, a nearby market is necessary. This is especially true for the study area because transportation is not efficient and refrigeration is rare.

In spite of all these favorable factors, well irrigation as a whole could not compete with the rapid extension of canals since the beginning of the present century. In the year 1890-91, before any large irrigation project was completed, 3,593,849 acres were irrigated in the upper Indus

⁸⁰Darling, op. cit., p. 95.

Basin and out of this total 2,162,653 acres were irrigated by wells. A decade later, when acreage under canal had increased to 2,529,117 the area irrigated by wells had declined to 1,681,654 acres. It was noted in the previous chapter that canal irrigation extended rapidly during the end of the nineteenth and the beginning of the twentieth century. Due to the superiority as well as the economy of canal water, wells were replaced by canals wherever it was possible. However, supplemental well irrigation remained in practice over the area with higher precipitation as well as in the areas where nonperennial canal irrigation was present.

The situation has changed appreciably during the 1950's and particularly in the 1960's. Certain problems produced by canals have been recognized and the use of ground water is considered more appropriate. Besides the disadvantages of canal irrigation discussed in Chapter II, it should also be noted that the farmers using canal water are permitted to withdraw water only in accordance with a rigid cycle of allocation which does not correspond to the extent of moisture depletion in their fields. Under this condition water can rarely be applied to the crops at the most appropriate time.⁸¹ The effect of this situation upon the agricultural pattern and the productivity can be realized. It is natural that the farmers do not invest in fertilizer or better farming equipment because they are not sure of the return on such investment. These were the conditions when the use of tubewells for irrigation was introduced. Government assistance and encouragement have helped to

⁸¹The White House Department of Interior Panel on Waterlogging and Salinity in West Pakistan, op. cit., p. 186.

spread tubewell irrigation in West Pakistan. According to an estimate, 31,500 tubewells had been installed by 1965 and 6,500 tubewells are being added annually. The import of the equipment and the availability of cheap electric power have made the installation of tubewells economical. Most of the wells at present are being installed by the private owners who have found them to be highly profitable.⁸²

The spatial distribution of the tubewells is not precisely known, but it has been found that generally these have been sunk where soil and water conditions are favorable and where more land is held in large enough units to make private development feasible. The ability to sink a private tubewell differs greatly with size of the farm. It was found that nearly eighty per cent of all tubewells were sunk by cultivators with holdings of twenty-five acres or more. The small peasant did not have enough cash to pay for a tubewell nor enough land to use it efficiently.⁸³ The divisions which have large farms and more potentialities for tubewell irrigation will be noted in the next chapter.

The future of tubewells appears to be brighter. According to an estimate, the installation of tubewells will become relatively cheaper due to the increasing cost of dam construction in the future. The value of canal water per acre foot is expected to be ten dollars as compared to four dollars per acre foot for the tubewell water.⁸⁴

⁸²Gustav F. Papanek, Pakistan Development: Social Goals and Private Incentives (Massachusetts: Harvard University Press, 1967), p. 109.

⁸³Ibid., pp. 176-178.

⁸⁴The White House Department of Interior Panel on Waterlogging and Salinity in West Pakistan, op. cit., p. 326.

Karez Irrigation

A karez is an underground channel dug by man to lead water from a natural underground reservoir to the surface a considerable distance away. The idea is that of a gently sloping tunnel, often along the radius of an alluvial fan.⁸⁵ The tunnel extends upslope until the water table is reached. To maintain the flow of water, it is necessary to keep a constant slope from the mouth of a karez to its source. Vertical shafts are dug at closely spaced intervals to give access to the surface. These shafts are used to dispose of the earth when the karez is constructed and are also used to clean the tunnel whenever it is necessary.

The origin and spread of this amazing type of irrigation has not been ascertained yet. However, most of the sources consulted agree that the original home of the karez might be Persia from which they spread into other parts of Asia and to Europe and America.⁸⁶ There is no direct evidence concerning how and when the karez or qanats were introduced into West Pakistan. However, the cultural diffusion between Persia and the southwest part of West Pakistan might be used as evidence in support of the thesis that karez irrigation reached West Pakistan from Persia.⁸⁷ According to Spate,⁸⁸ karez irrigation originated in the subcontinent, but this view seems to be incorrect because all the literature consulted

⁸⁵G. B. Cressey, "Qanats, Karez, and Goffaras," Geographical Review LXVIII (January, 1958), p. 27.

⁸⁶Ibid; and Helmut Klaubert, "Qanats in An Area of Pavia-Bohemia," Geographical Review, LXVII (April, 1967), 203.

⁸⁷Stuart Pigott, Prehistoric India (Baltimore: Penguin Books, 1961), p. 218.

⁸⁸Spate, op. cit., p. 429.

by this writer about the prehistoric irrigation in the subcontinent gives no evidence to support this idea. Interestingly, it appears that the karez reached this area very late. It has been found that, in spite of early cultural diffusion, the concept of the karez reached Baluchistan only in the second half of the seventeenth century when Nadir Shah Irani attacked India. He is reported to have passed through Baluchistan where his soldiers introduced the karez for the first time.⁸⁹

After its introduction, karez irrigation spread fairly rapidly. According to Buckley six million acres were irrigated by springs and karez in the subcontinent about 1900.⁹⁰ A census of the administrative area of Baluchistan in 1903 reported 493 karez.⁹¹ The number of karez reported in 1956 was six hundred and, along with some springs, they irrigated an area of three hundred thousand acres.⁹²

The factors which account for the existence of karez irrigation even today are political, economic and physical. It was noted earlier that in the development of irrigation Baluchistan, due to political insignificance, did not attract the attention of the governments. As a result, people had to get water for drinking and irrigation with any method they knew and from anywhere the water was available. High water

⁸⁹ Personal Communication with I. M. Khan, Principal of a High School in Quetta dated July 28, 1968.

⁹⁰ Buckley, op. cit., p. 3-4.

⁹¹ Cressey, op. cit., p. 41.

⁹² Water Resources Development in Burma, India and Pakistan, Multipurpose River Basin Development - Part 2B (U.N. Economic Commission for Asia and the Far East, 1961), p. 113.

table is anticipated in the mountains of Baluchistan from the evidence that in certain areas as much as sixty per cent of the rainfall is lost by percolation. Besides, in some areas very high velocity dry winds make it necessary to transport water underground through channels.⁹³ Economically, the karez system is considered suitable for a feudal system under which holdings are large and the owners can afford to undertake this slow and expensive method of irrigation.⁹⁴ It will be noted in the next chapter that size of the farm is appreciably large in Baluchistan.

In 1960 West Pakistan had 1,893,234 acres irrigated by means other than canals and/or wells. The Census of Agriculture, while defining the terms, described karez as the third most important source of irrigation. It appears that the area irrigated by tanks and direct lift from rivers (if any) is also included in the total given above. However, tanks are rarely of any importance now,⁹⁵ and irrigation by direct lift from rivers is feasible only in those divisions where the major rivers exist.

The map (Fig. IV) does not show the area solely irrigated by karez. However, it is important to note that on the one hand karez irrigation is found only in Quetta and Kalat divisions, and on the other hand, as noted earlier, karez command considerable acreage in these two divisions.

⁹³S. I. Siddiqi, "Water Resources and Their Conservation in the Mastung Valley," The Oriental Geographer (July, 1962), pp. 162-164.

⁹⁴C. B. Fisher, "Irrigation System of Persia," Geographical Review, XVIII (April, 1928), p. 305.

⁹⁵Akhtar, op. cit., p. 87.

The situation has changed since about 1960, when the government started to give attention to extending modern well and canal irrigation to all the areas previously neglected. However, the planners have also been anticipating the continued use of karez for irrigation. Suggestions have been made for the modernization of karez by installing concrete pipes in the tunnels to reduce seepage losses and also to get rid of the cleaning which is a dangerous and expensive operation.⁹⁶

It appears doubtful that in the presence of modern canal and well irrigation there would be any improvement in this primitive type of irrigation. In fact, most of the karez have already gone out of operation,⁹⁷ and as the well and canal irrigation is being extended in Quetta and Kalat divisions, the future of karez irrigation is dark. Probably karez irrigation will be finished in the near future.

⁹⁶M. R. Huberty, "Nature and Extent of FAO's Ground Water Studies," Desert Research (Jerusalem: Israel Research Council, 1953), p. 380.

⁹⁷Siddiqi, op. cit., p. 167.

CHAPTER IV

IRRIGATION AND FARM SIZE

Farming is considered a cultural process; it implies a functional relationship between man and land. This relationship reflects the interaction of technology with the environment in a given society and creates observable imprints in the form of farms.⁹⁸ The farms function as a base for the complicated process of agriculture. They are of different sizes and constitute an important feature of the agrarian landscape.

The following pages are concerned mainly with the interaction between irrigation and farm size, but other factors have also been considered where necessary, because one cannot expect to find a single reason that explains the spatial variation of farm sizes.⁹⁹

Spatial Pattern

Before describing and interpreting the relation between irrigation and farm size, it is necessary to discuss the spatial distribution of the farms of different sizes. Pakistan Agricultural Census Organization has classified all farms in West Pakistan as small, medium and large. The average size of a small farm is 1.9 acres, that of a medium farm is 11.3 and that of a large farm is 53.9 acres. Any farm smaller than five acres

⁹⁸A farm as defined in this study is the aggregate area of land operated by one person alone or with the assistance of others and used wholly or partly for agriculture.

⁹⁹David Grigg, "The Geography of Farm Sizes: A Preliminary Survey," Economic Geography, XLII (July, 1966), p. 228.

is included in small farms while any farm larger than twenty-five acres is included in large farms.¹⁰⁰ The exact figures for the size of the smallest and the largest farms found in West Pakistan are not available; however, there are farms smaller than one acre and larger than ten thousand acres.¹⁰¹

As a whole, small farms comprise forty-nine per cent of the total number of farms in West Pakistan, but they occupy only nine per cent of the total farm area. Medium and large farms account for forty-three per cent and eight per cent of the total number of farms, and they occupy forty-eight and forty-three per cent of the total farm area, respectively. These figures show that the distribution of land is uneven and that numerically the small farms dominate in the agriculture of West Pakistan. The same thing was subjectively expressed by Link when he said that, "to a Pakistani, forty acres would be the equivalent of the King Ranch in Texas."¹⁰²

Complying with the general trend to go beyond the use of numbers and simple percentages in geographic studies, an attempt has been made to analyze the divisional distribution pattern of the farm sizes in West Pakistan. The divisional distribution of small, large and medium farms has been investigated quantitatively, and spatial dominance of the

¹⁰⁰ I. H. Zaidi, "The Spatial Pattern of Farm Sizes in the Punjab Region of West Pakistan," Pakistan Geographical Review, XXII (July, 1967), p. 67.

¹⁰¹ Third Regional Irrigation Practices Seminar NESA Regions (Lahore: Government of Pakistan and U.S. International Cooperation Administration, 1960), p. 92; and Tayyeb, op. cit., p. 135.

¹⁰² O. F. Link, A Passage Through Pakistan (Detroit: Wayne University Press, 1959), p. 14.

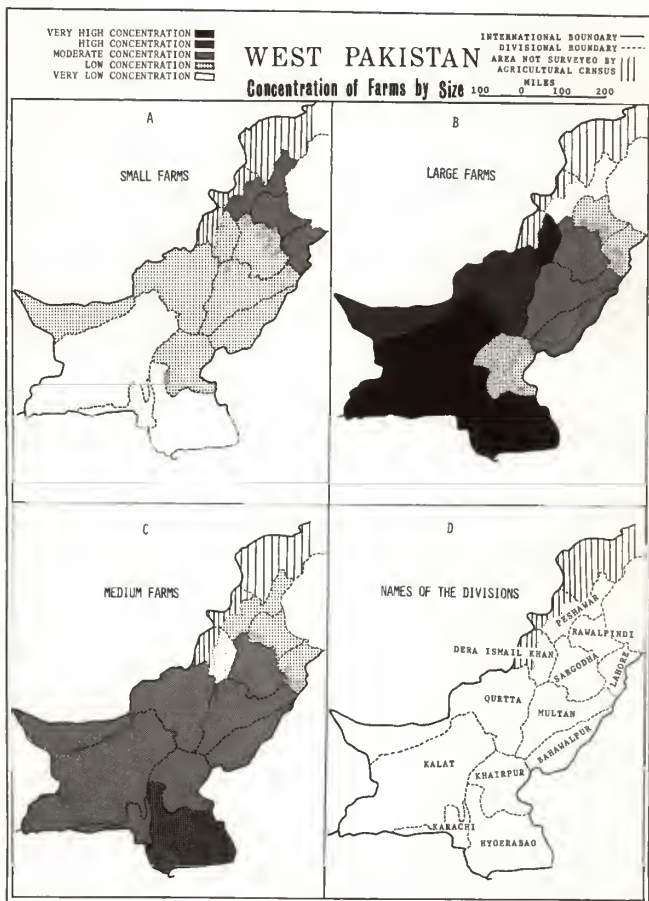
types of farms has been determined first by comparing the number of each type with the total number of farms in each division and then by relating that ratio to the corresponding ratio for West Pakistan.

In order to determine the divisional concentration of a farm type, an index (concentration index) has been calculated.¹⁰³ The index values for all types of farms have been calculated for each division of the province.¹⁰⁴ These values have been then arranged in descending order and divided into five equal parts to show the degree of concentration.¹⁰⁵ The maps (Fig. V) are revealing and perhaps offer a new approach for this kind of study.

103	Concentration Index of x farms in a division	=	$\frac{\text{No. of x farmsin the division}}{\text{No. of all farmsin the division}}$	÷	$\frac{\text{No. of x farmsin West Pakistan}}{\text{No. of all farmsin West Pakistan}}$
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¹⁰⁴ Similar methods have been used by W. D. Jones, "An Isoleth Map of Land Under Crops in India," Geographical Review, XIX (1929), 495-96; and S. S. Bhatia, "Pattern of Crop Concentration and Diversification in India," Economic Geography, XLI (January, 1965), 39-56.

105	<u>Degree of Concentration</u>	<u>Concentration Index</u>
	Very High	More than 2
	High	2 - 1.5
	Moderate	1.5 - 1.0
	Low	1.0 - 0.5
	Very Low	Less than 0.5



Small Farms

As shown on the map (Fig. V-A), small farms fall into three categories only, and even in these three categories the variation of concentration from one division to the other is gradual. Concentration varies only from moderate (1.5 - 1) to very low (less than 0.5). This shows that small farms are widely distributed throughout the province. Except for three submontane divisions (Peshawar, Rawalpindi and Lahore) and three southern divisions (Kalat, Karachi and Hyderabad), small farms are almost uniformly distributed. However, it should not be overlooked that within the divisions showing the same level of concentration, there are variations. The index for Multan is as high as 0.98 and that for Bahawalpur is 0.92 while the lowest index is 0.67 for Khairpur. This shows that, in general, the concentration of small farms in these three divisions places them closer to the higher category (index 1.5 - 1) than to the lower one (less than 0.5).

Small farms show moderate concentration over only the northeastern submontane divisions of Peshawar, Rawalpindi and Lahore. Within these divisions, concentration is maximum near the mountains and diminishes with distance from the mountains.¹⁰⁶ Excluding Peshawar Division, the highest concentration of small farms throughout West Pakistan is found in the Sialkot and Gujrat districts located in the extreme northeastern sections of Lahore and Rawalpindi divisions, respectively.

The three southern divisions with very weak concentration do not

¹⁰⁶Zaidi, op. cit., p. 66.

show much variation. Considering the concentration indexes, inter-divisional variation is least for this area. This indicates greater similarity among Hyderabad, Karachi, and Kalat divisions as far as the concentrations of small farms is concerned.

Large Farms

Spatial patterns of large farms are different from those of small as well as medium farms. The map (Fig. V-B) is the only one on which all five categories of concentration are represented. If compared with either of the other two maps on the same page, the large-farm map does not follow the patterns present on those maps. There are areas on the large-farm map showing the same shade which they show in either the small or medium-farm map. The division of Hyderabad is under the same shade on the small-size as well as the large-size farm map while Rawalpindi, Lahore, Sargodha, Multan and Bahawalpur are under the same shade on the medium and large farm maps. Similarly the divisions with a concentration index of more than one in the case of large farms might remain in the same category on either of the other two maps. This is also true for the divisions with the concentration index of less than one. This shows that large farms can be located in any division irrespective of the presence or absence of the other types of farms. In other words, there is no competition between large farms and either the medium or small farms.

Medium Farms

The concentration of medium farms (Fig. V-C) varies from high to very low. Only one division shows very low concentration and similarly

one division shows high concentration. Medium farms show low concentration over the three submontane divisions, while in the rest of the province, with the exception of Dera Ismail Khan and Hyderabad, medium farms show moderate concentration. Within the area of moderate concentration of medium farms, concentration varies and is maximum for Khairpur Division.

A comparison of figures V-A and V-C is interesting. There is not a single division with the same degree of concentration of farms in these two size categories. It appears as if both types of farms tend to be located in the same area of a division and if, due to certain reasons, one type dominates, the other is dominated. Perhaps the same factor or factors influence the location of both small and medium farms. This thesis is further supported by the fact that the divisions where small farms dominate (concentration index more than 1.0) show weak concentration (concentration index less than 1.0) of medium farms. Similarly the reverse is also true. The only exception to this is that of the Dera Ismail Khan Division, which shows a weak concentration (concentration index less than 1.0) of both small and medium farms.

When all three maps are considered together, certain divisions are grouped together. The divisions of Peshawar, Rawalpindi and Lahore remain together on the maps of small and large farms. Sargodha, Multan and Bahawalpur seem to be specially tied together because they appear as a group on all the maps. Applying the same criterion to Hyderabad, Karachi and Kalat, one observes that these divisions also form a group and the relationship is closer between Karachi and Kalat.

After discussing the existing spatial patterns of farm types, it is proper now to interpret the observations and look for the causes. The area over which small farms are dominant has some other common characteristics. It was noted earlier (Fig. IV) that well irrigation dominates in this area. This factor has a definite bearing upon the concentration of small farms. Writing about the concept of land ownership in Punjab, Trevaskis concluded that the concept of land ownership began in this area with the making of canals and the digging of wells.¹⁰⁷ This seems to be a reasonable conclusion because when a man spends his earnings or energy for the construction of an irrigation work, he must claim some sort of control over the area served by that water. This is not necessary for the area cultivated with the help of precipitation only, because under the conditions existing during the early period of settlement, it was not necessary to stick to a piece of land. A long history of the occupancy of the submontane area shows that the settlement must have started here very early when there was a low population density and therefore an abundance of land.¹⁰⁸ After the cultivators were settled, there was no choice but to divide the land among themselves, because there were no more chances of shifting agriculture. In the beginning, due to low population density, the size of farms must have been larger than what it is today. However, population in this area increased very rapidly. For instance, the population density in

¹⁰⁷Trevaskis, op. cit., p. 70.

¹⁰⁸Zaidi, op. cit., p. 73.

Sialkot District of Lahore Division was 554 per square mile in 1831 and increased to 610 in 1891.¹⁰⁹ This density was higher than any other district at that time, and the rate of population increase was among the highest.¹¹⁰ Since the beginning of the present century, however, due to the extension of canal irrigation, population increased more rapidly in other areas; but the density of population remained highest for Sialkot. The results of high population density and rapid increase of population over an agricultural area are undoubtedly the subdivision of agricultural holdings and, consequently, smaller farms. This is true for all the countries with similar conditions.¹¹¹

In general, the rapid increase of population in the submontane area is related to well irrigation. This area was densely populated before the beginning of modern canal irrigation.¹¹² It was indicated in the previous chapter that wells were serving a maximum area in the subcontinent about the end of the nineteenth century. This period obviously coincides with the maximum population increase in the submontane area. Viewed from another angle, the density of population in the subcontinent has been a function of fertility of the land, and fertility in the submontane areas is high; Darling found it comparable to that of Lombardy.¹¹³

¹⁰⁹ It was noted earlier that Sialkot has the highest intensity of well irrigation.

¹¹⁰ Malik, op. cit., p. 144.

¹¹¹ General Introduction: Number and Size of Holdings. World Agricultural Study No. 1 (Rome: FAO of the United Nations, 1961), p. 40.

¹¹² Spate, op. cit., p. 774.

¹¹³ Darling, op. cit., pp. 24-25.

Fertility affects the population through the productivity of land, and the productivity of land throughout West Pakistan directly depends upon irrigation. Agricultural productivity was objectively measured in West Pakistan, and, if the districts are arranged in descending order of productivity, the intensity of irrigation goes on decreasing in the same order.¹¹⁴ Of course, there is no appreciable difference in productivity so far as the sources of irrigation water are concerned, but as the well irrigation is older than any other type, it has influenced the population density and, ultimately, the size of farms in areas where it has been dominant. Besides this indirect influence, wells directly influence the size of farms through the number of acres a well can irrigate. It was observed by Clark that in many parts of Punjab the average size of holdings depends upon the quantity of water that two bullocks can draw from a well.¹¹⁵ In light of the above discussion it might be concluded that the high concentration of small farms in West Pakistan is related to well irrigation.

The area showing low concentration of small farms, with the exception of Quetta and Dera Ismail Khan divisions, is such that it has a very high irrigation intensity (Fig. I). Within all the divisions in this area, the intensity of irrigation is highest in Multan Division. It was noted above that small farms are also comparatively more

¹¹⁴I. H. Zaidi, "Towards a Measure of Functional Effectiveness of a State: The Case of West Pakistan," Annals of the Association of American Geographers, LVI (March, 1966), p. 59.

¹¹⁵Colin Clark, The Economics of Irrigation (New York: Pergamon Press, 1967), p. 54.

concentrated there, and this division barely missed the moderate concentration category. Further investigation on district bases shows that throughout this area (low concentration), either the district with highest concentration of small farms in each division has the highest irrigation intensity, or the first and second districts in both cases are interchangeable. This simply shows that high intensity of irrigation, regardless of its type, tends to reduce the size of farms.

The exceptional cases of Quetta and Dera Ismail Khan divisions can be explained by referring to the map (Fig. II). Both of these divisions receive a higher precipitation which is comparatively even in distribution as well. This might be the reason for the higher population density in parts of these divisions and, consequently, the smaller farms. Population density in Quetta and Dera Ismail Khan divisions is higher than that in Karachi and Kalat divisions.¹¹⁶ This difference is present in spite of the same irrigation intensity in these four divisions. In Quetta Division, along with climate, the irregular surface and isolated cultivable areas were also found to encourage smaller farms.¹¹⁷

Another exception is that of the Hyderabad Division. In spite of a higher irrigation intensity, this division is grouped with the divisions showing very weak concentration of small farms. There are two reasons for this. First, the extension of modern irrigation, as noted

¹¹⁶ K. S. Ahmad, A Geography of Pakistan (Lahore: Oxford University Press, 1964), p. 146.

¹¹⁷ Whyte, op. cit., p. 162.

earlier, began very late in this area; and second, in irrigated areas of the Lower Indus Basin, huge grants were made to a handful of people, consisting mainly of the old established aristocratic families.¹¹⁸ To appreciate the influence of the first factor, one should realize that it takes some time before the effect of irrigation becomes observable on the size of farms in an area. It is only a matter of time, however, until the large and medium farms in an irrigated area shrink and become small. This time influence can be illustrated by the fact that in 1924 the average size of a farm in the canal-irrigated Layalpur District (Multan Division) was eighteen acres, and at the time of the census (1960) it had been reduced to 8.8 acres.¹¹⁹ Another reason for the low concentration of small farms in Hyderabad might be the dominance of nonperennial irrigation in the Lower Indus Basin. The influence of nonperennial irrigation upon the size of the farms is reflected by the statement of a member of the Land Reform Commission who recommended considering one acre of perennially irrigated land equal to one and one-half acres of nonperennially irrigated land.¹²⁰

As for the distribution of large farms, the divisions with lowest concentration are generally the ones which have highest concentration of small farms. This probably means that the causes for the concentration of large farms are different from those for the concentration of small

¹¹⁸Tayyeb, op. cit., p. 135.

¹¹⁹Darling, op. cit., p. 127.

¹²⁰Akhtar, op. cit., p. 164.

farms. A comparison of the figure V-B with figures I, II and IV shows that there are differences of climate, irrigation intensity, and types of irrigation between the areas which show marked differences in the concentration of large farms. As seen above, the combined effect of higher precipitation and higher irrigation intensity in general, and the presence of well irrigation in particular, is responsible for the dominance of small farms. The absence of these very factors seems to encourage the concentration of the large farms. Low irrigation intensity, however, appears to dominate all other factors; the inverse relationship between the degree of concentration of large farms and the intensity of irrigation is observable throughout West Pakistan. To be more precise, the division of Karachi has the lowest intensity of irrigation and the highest concentration index (3.87) for large farms. Dry farming, besides being low in productivity, is precarious and a farmer must have plenty of land to survive the lean years of drought. The farms ought to be larger, and there should also be some extremely large farms, so that at a time of scarcity there would be some men of substance whose food surpluses could assist the cultivators.¹²¹ The necessity of having larger farms in unirrigated areas is also reflected by the land reform regulations in West Pakistan. According to these regulations, ceilings have been placed on the holdings at five hundred acres of irrigated land or one thousand acres of unirrigated land.¹²²

¹²¹Ibid., p. 99.

¹²²Akhtar, op. cit., p. 159.

The types of irrigation do not show a direct relationship to the concentration of large farms. However, it was noted in a previous chapter that karez irrigation was suitable for the feudal system under which the holdings are very large. The divisions of Quetta and Kalat have large farms and the structure of society is also tribal.¹²³ This might explain the presence of karez irrigation in this area.

Certain divisions, as noted earlier, have about the same concentration of each of the three farm sizes (Fig. V-A, V-B and V-C). This is a result of the existence of some unirrigated areas in every division. Small and medium farms are located over irrigated areas while large farms are found over unirrigated areas. Another reason for the presence of large farms in every division is the practice of allotting large holdings to government officers, a policy followed by most of the rulers of the subcontinent.¹²⁴

The distribution of medium farms is comparatively uniform. A precise evidence of this is that the difference between the highest and lowest concentration indexes is smallest in the case of medium farms. Another proof of the comparative uniformity of the pattern is the maximum area with the same degree of concentration (Fig. V-C). When comparisons are made, medium farms show a pattern different from that observed for large and small farms. Medium farms, in fact, are transitional between large and small farms. When irrigation is introduced

¹²³Whyte, *op. cit.*, p. 114.

¹²⁴*Ibid.*, pp. 112-113.

into a dry area, large farms are changed to medium farms, which ultimately change to small farms. This process can clearly be observed in the canal colony divisions of Multan, Bahawalpur and Sargodha. It might be recalled here that, as observed in Chapter II, these divisions have been under high irrigation intensity for a long time. It was also noted above that these three divisions are well integrated as far as the concentration of farms is concerned.

If the position of these three divisions is considered on all the maps showing concentration of farms (Fig. V) it is seen that small and medium farms are dominant as compared to large farms. On figures V-A and V-C these divisions come under the degree of concentration which is second to the highest degree of concentration present on both maps, while on the map showing the concentration of large farms, the same divisions come under the degree of concentration which is third from the highest. If the variation of concentration within the divisions of Multan, Bahawalpur and Sargodha is considered, the concentration index for Multan is seen to be higher than that for the others.¹²⁵ The difference between Multan and the other two divisions is that Multan got irrigation earlier than the others. This shows that irrigation, with the passage of time, encourages reduction in the size of farms.

The presence of considerable numbers of medium farms in each division, as well as their uniform distribution throughout the province, is a result of the difference between the definition of a medium and

¹²⁵ Multan = 0.98, Bahawalpur = 0.92 and Sargodha = 0.79.

a small farm, and the size of the farms allotted to the settlers in the newly irrigated areas. Any farm between five and twenty-five acres is a medium farm, and as the size of the farms allotted in canal colonies varies from 22.5 to 27.8 acres, a considerable time is required for a medium farm to enter into the lower size category.¹²⁶

The distribution pattern of the types of farms in West Pakistan and certain characteristics of irrigation have more or less determined the crop pattern in the province. This aspect of irrigation-agriculture will be examined in the following chapter.

¹²⁶Paustian, *op. cit.*, p. 64.

CHAPTER V

IRRIGATION AND CROPS

Geographers in general and agricultural geographers in particular have always been interested in crops. However, due to the dynamic nature of geography, the role of crops has been changing according to the interests of agricultural geographers. In the early twentieth century, when the commodity approach was common in geography, crops were important primarily as commodity suppliers. After this, the works of Derwent Whittlesey and contemporary geographers describe a more precise role of crops in the spatial differentiation of agricultural landscape. Recent trends to make geography more objective and scientific have increased the importance of crops; John C. Weaver, while comparing the elements of agricultural geography with chemical elements, has described crops as the most obviously definable elements.¹²⁷

In West Pakistan, as in many other places, the differences and similarities of agricultural landscape from place to place reflect the impact of physical and cultural influences. The factors affecting the distribution of crops are numerous, but the heavy dependency upon water, as observed in the second chapter, makes irrigation a factor deserving special consideration. It was noted earlier that with the extension of irrigation the cultivated area increases more rapidly than the irrigated area. The characteristics of irrigation which are important as far as

¹²⁷ John C. Weaver, "A Design for Research in the Geography of Agriculture," The Professional Geographer, X (January. 1958), p. 7.

the crops are concerned are the availability, quantity, and reliability of water. As these characteristics are different in various parts of West Pakistan, spatial variation is observed in crops and their importance. It has been found that the area planted to major crops is fairly well adjusted to the supplies of water normally available.¹²⁸ These adjustments are made by selecting the crops with sowing, growing and harvesting seasons as well as moisture requirement according to dependability and quantity of water available.

Crop Seasons

There are two important crop seasons in West Pakistan; these are known as rabi and kharif. Rabi is the winter season beginning in October-November and ending in April-May, while kharif is the summer season beginning in April-June and ending in October-November.

The crops associated with these two seasons are significantly different as far as their requirements are concerned. Those crops which do not require much water and do well at lower temperatures are grown during rabi, while the others requiring plenty of water and higher temperature are grown during kharif. The important rabi crops are wheat, gram, and oilseeds; important kharif crops are cotton, sugar cane, rice, and corn. This is a valid classification in spite of the fact that some of the crops do not seem to fit exactly into either category because they extend into both seasons. Sugar cane and cotton are two crops of

¹²⁸The White House Department of Interior Panel on Waterlogging and Salinity in West Pakistan, op. cit., p. 188.

this type. The sowing time of cotton is in February and March, while both sugar cane and cotton might still be in the fields and need water when kharif has begun.¹²⁹ Fodder is also difficult to classify since certain crops used as fodder are grown in both seasons and so can be grouped with either.

Crop Pattern

An important preliminary step in the interpretation of geographic elements is to show them on a map. Geographers have used various techniques to map the distribution of crops. Perhaps one of the most widely used was the dot method, still common in textbooks. The use of statistics and the development of better mapping techniques have, however, made this method obsolete, at least for research purposes. Geographers have realized that observations concerning a single crop without reference to its immediate cultivated companions are not of much use because rarely does a crop assume a position approximating absolute isolation.¹³⁰ Because of such a necessary association between crops, any successful attempt to understand the geographic patterns must take into consideration all the crops grown over the area being studied.

The method used here to map the crops grown in West Pakistan is similar to the one used in Chapter IV. The same technique has been used to bring out the significance of a crop in a division. The index of

¹²⁹ Third Regional Irrigation Practices Seminar - NESA Regions.
op. cit., o. 96.

¹³⁰ John C. Weaver, "Crop Combination Regions in the Middle West," Geographical Review, XLIV (April, 1954), p. 175.

concentration calculated is a value which shows the importance of a crop as compared with the other crops in a division as well as the comparative position of the same crop throughout West Pakistan.¹³¹ The concentration index for each important crop grown in every division has been calculated, and the indexes have been divided into four parts and arranged in descending order.¹³²

The total number of crops given in the 1960 Census of Agriculture is ten. Some crops are grouped together and labeled as "other crops," apparently such crops are not important. The number of crops considered in this study is eight; the crops not considered are fruits and bajra. They are omitted because they occupy only a small percentage of the cropped area and also do not show accordance with irrigation. Each of the crops has been described and interpreted with reference to irrigation as well as other factors whenever necessary.

¹³¹Concentration Index for Crop x =

$$\frac{\begin{array}{l} \text{Area under crop x} \\ \text{in a division} \end{array}}{\begin{array}{l} \text{Area under all crops} \\ \text{in the division} \end{array}} \div \frac{\begin{array}{l} \text{Area under crop x} \\ \text{in West Pakistan} \end{array}}{\begin{array}{l} \text{Area under all crops} \\ \text{in West Pakistan} \end{array}}$$

¹³²Degree of Concentration

Very high concentration
High concentration
Moderate concentration
Some production

Concentration Index

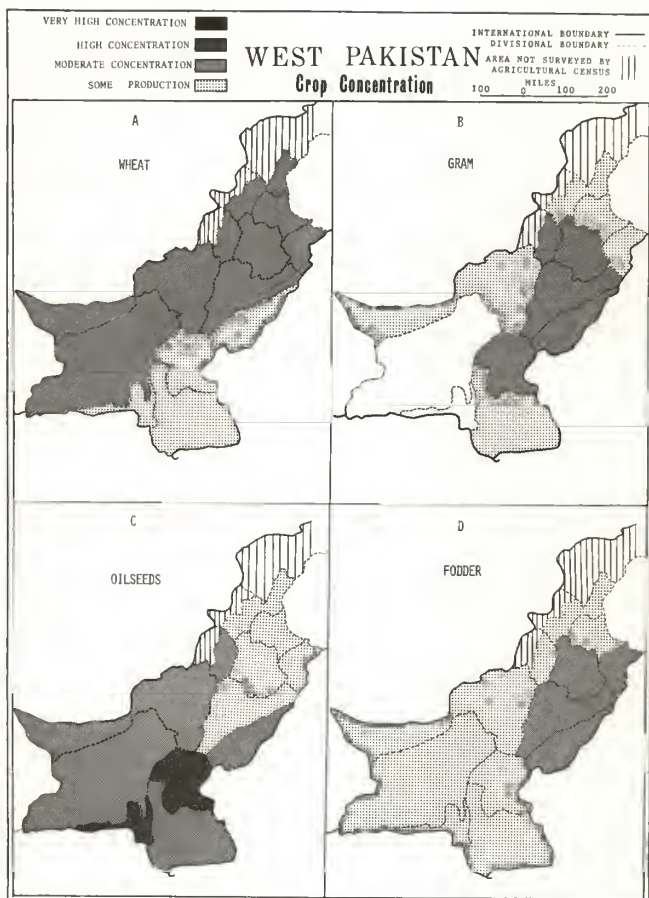
above 3.9
2.5 - 3.9
1.0 - 2.4
below 1.0

Wheat. Wheat commands a special position in the crop complex of West Pakistan. It is one of the earliest as well as the most important crop being cultivated there. Indications are, however, that wheat is not indigenous to the subcontinent and that it was introduced from Afghanistan through the passes in the Northwest of West Pakistan.¹³³ Presently, wheat occupies thirty-four per cent of the total cropped area in West Pakistan. This is considerably more than double that of any other single crop grown in the province. To realize the importance of wheat, one might note that Pakistan is the tenth largest producer of this grain in the world.¹³⁴

Wheat is very widely grown in West Pakistan. In nine of the twelve divisions of the province, it commands the first position, while each of the rest has a considerable area under wheat. The map (Fig. VI -A) shows that the distribution of wheat is nearly uniform in West Pakistan. There are only two shades, representing two consecutive concentration categories, and of these two, the one which represents moderate concentration is predominant. In fact, there is no other crop so uniformly distributed as wheat. Of the four divisions showing some production, Bahawalpur, with concentration index 0.91, hardly fits into this category. Within the divisions showing moderate concentration, the index of concentration is highest (1.73) for Dera Ismail Khan and lowest (1.02) for Lahore.

¹³³Whyte, *op. cit.*, p. 161.

¹³⁴Harry Robinson, Monsoon Asia: A Geographical Survey (New York: Fredrick A. Praeger Publishers, 1966), p. 193.



If this map is compared with figure I (irrigation intensity), certain correlations can be recognized. With the exception of Karachi, Dera Ismail Khan has a distinctive position on both maps.¹³⁵ It has the lowest intensity of irrigation and the highest concentration of wheat. Similarly, the inverse relationship between the intensity of irrigation and the concentration of wheat is demonstrated within this division. The district with the lowest intensity of irrigation has the highest concentration of wheat. This inverse relationship between irrigation and concentration of wheat is generally true throughout the divisions showing a higher concentration (index above 1) of wheat. Except for Kalat, either the district with the highest concentration of wheat in each division has the lowest irrigation intensity or vice versa. The deviation of Kalat from the general trend is not important because, like Karachi, this division has an insignificant area under cultivation.

Considering the divisions with some production, it was noted above that Bahawalpur does not fit into this category and Karachi is an exceptional case. So, in fact, lower concentration or some production is found only in two divisions. The reasons for the lower concentration of wheat in Khairpur and Hyderabad are the higher temperature and concentration of salts in the soils.¹³⁶ Wheat, being a rabi crop, does not do well under high temperature and is sensitive to saline soils.¹³⁷

¹³⁵Karachi can be taken as an exception because it is obvious (Fig. I) that agriculture is insignificant in this division.

¹³⁶Ahmad, *op. cit.*, pp. 31-32.

¹³⁷Salinity Problems in Arid Zone: Proceedings of the Tehran Symposium (UNESCO, 1961), p. 190.

The above discussion has shown that the introduction of irrigation tends to reduce the area under wheat. However, it should also be noted that a major portion (about thirty-six per cent) of the area under wheat is irrigated. One of the principal reasons for reducing the importance of wheat in irrigated areas is that wheat under irrigation cannot compete with other more paying crops. It was noted in an earlier chapter that the productivity of agriculture increases with irrigation intensity in West Pakistan. An increase in productivity reduces the importance of wheat because it is only economical on the soils with lower productivity.¹³⁸ Increased productivity favors the crops which pay more and thus reduces the importance of wheat.

Another type of relation between irrigation and wheat is an indirect one determined through the size of the farms. As noted in Chapter IV, Dera Ismail Khan is among the divisions with the highest concentration of large farms while Lahore is among the divisions with the lowest concentration of large farms. This shows the direct relationship between concentration of wheat and that of large farms. Because wheat has been found to be suitable for extensive cultivation, it usually is displaced by more valuable crops as the farms become smaller.¹³⁹ As the concentration of large farms is due to low irrigation intensity (Ch. IV), the accordance between wheat cultivation and low irrigation intensity can be realized.

¹³⁸Weaver, op. cit., pp. 236-37.

¹³⁹H. Calvert, The Wealth and Welfare of the Punjab (Lahore: Civil and Military Gazette Press, 1922), p. 72.

The cultivation of wheat has also been influenced by factors other than irrigation. Wheat is one of the crops which demands little labor. Once it has been sown, it requires little additional care by the farmer until the harvest is ready.¹⁴⁰ The fact that some wheat is grown even on small farms in irrigated areas indicates that the cultivator, at least to some extent, attaches more importance to traditional and social values than to economic considerations.¹⁴¹

Another reason for the cultivation of wheat in irrigated areas is the deficiency of irrigation water in the dry season and the surplus of water in the short rainy season. In the rainy season farmers usually irrigate more area than they cultivate and conserve the moisture which enables them to sow wheat in the beginning of autumn. This conserved moisture is enough to mature at least a poor crop of wheat.¹⁴² Thus the deficiency of water in irrigated areas favors the cultivation of wheat. Probably because of this reason, wheat is usually considered to be the most economic user of water in West Pakistan.¹⁴³

Gram. Gram occupies seven per cent of the total cropped area in West Pakistan. It has been grown in the Indus Valley since the time of

¹⁴⁰David Dichter, The Northwest Frontier of West Pakistan: A Study in Regional Geography (Oxford: Clarendon Press, 1967), p. 160.

¹⁴¹Papanek, op. cit., p. 143.

¹⁴²Buckley, op. cit., p. 22.

¹⁴³A. G. Asghar, "Progress of Land Reclamation in West Pakistan," Fourth Irrigation Practices Seminar (Ankara: Regional NESAL Leadership Seminar, 1962), p. 231.

Mohenjo daro and Harappa civilizations.¹⁴⁴

Besides being used as human food, gram is an important cattle feed. Being a leguminous plant, it is also grown to restore soil fertility. Like wheat, gram is considered an economic user of water. In certain cases, returns per acre inch of water have been found to be highest for gram.¹⁴⁵

Spatial concentration of gram (Fig. VI-B) shows certain similarities as well as dissimilarities to that of wheat. For example, four divisions on each of the maps show the same concentration. Dera Ismail Khan Division shows the highest concentration of wheat and the same division has the highest concentration of gram.

As far as the dissimilarities are concerned, cultivation of gram appears to be less suited for small farms. This can be observed by a comparison of the maps showing concentration of small farms and that of gram. The divisions showing a minimum concentration of gram (Fig. VI-B) have a maximum concentration of small farms (Fig. V-A). Even within this group of divisions, Peshawar has a maximum concentration of small farms and a minimum concentration of gram. The next dissimilarity between the patterns of wheat and gram can be observed by comparing the concentration of gram with the intensity of irrigation. In general the divisions with higher concentration of gram have a higher irrigation intensity. It does not mean, however, that the gram is cultivated only on the irrigated

¹⁴⁴Sir Mortimer Wheeler, The Indian Civilization (Cambridge: The University Press, 1962), p. 67.

¹⁴⁵Asghar, op. cit., p. 231.

area, but at least one can say that the inverse relationship observed between wheat and irrigation is not true for gram.

Similarities of wheat and gram concentration might be due to the low water requirement and the hardier nature of both these crops. Dissimilarities might be due to the fact that gram is not a common food grain; it restores soil fertility and to some extent is a cash crop. Gram is also cultivated in rotation with wheat, and it does well even on less fertile soils.¹⁴⁶

Oilseeds. Although some varieties are grown in the summer, oilseeds are classified as a rabi crop because ninety-two per cent of these are grown in the winter season.

The most important use of oilseeds in the subcontinent is as suppliers of vegetable oil.¹⁴⁷ Although some are used by the cultivator, most of the oilseeds enter the market and are therefore a cash crop.¹⁴⁸ Since prehistoric times, oilseeds have remained an important crop of the agricultural complex of this region. Strabo, one of the Greek scholars, mentions that oilseeds were grown in the Indus Valley at the time of Alexander's invasion.¹⁴⁹

Presently, only four per cent of the total cropped area of West

¹⁴⁶ Malik, *op. cit.*, p. 124.

¹⁴⁷ Samuel Van Valkenburg, "Agricultural Regions of Asia: Part IV: India," *Economic Geography*, IX (April, 1933), p. 130.

¹⁴⁸ Spate, *op. cit.*, p. 242.

¹⁴⁹ Whyte, *op. cit.*, p. 111.

Pakistan grows oilseeds, but since oilseeds are a cash crop in a partly commercialized agriculture, they are important and are grown throughout the province. Although the pattern (Fig. VI-C) does not show significant accordance with irrigation, oilseeds are equally important on irrigated land, because some divisions showing the highest concentration of oilseeds have very high irrigation intensity. Even on the district basis, certain districts with virtually no unirrigated cultivated area grow oilseeds. Additional evidence of the preference for oilseeds on irrigated farms is provided by the fact that between 1905 and 1946, the area under oilseeds in two of the most important canal colony districts of Multan Division increased from eleven per cent and 1.5 per cent to twenty-two and twenty-one per cent, respectively.¹⁵⁰ It was found earlier that between 1905 and 1946, irrigation extended very rapidly. The preference for sowing oilseeds in irrigated areas seems to be due to the necessity for growing a cash crop and to the small amount of water they require. Like wheat, oilseeds can also be grown over the land with conserved moisture from the high water period of canals, because after they are sowed, they can mature even without irrigation.¹⁵¹

The patterns in the case of oilseeds (Fig. VI-C) show a recognizable relationship to the concentration of large farms. If figures VI-C is compared with figures V-B and V-C, it becomes clear that there

¹⁵⁰ Malik, *op. cit.*, pp. 132-34.

¹⁵¹A. Hafiz, "Methods for Solving the Problem of Water Shortage in Winter Crops," Plant-Water Relationships in Arid and Semi-Arid Conditions (Proceedings of the Symposium, Madrid, 1961), p. 248.

is a preference for oilseeds in the divisions having a higher concentration of large farms. This view is also supported by the fact that, out of the total area under oilseeds in West Pakistan, only about seven per cent is in small farms and the rest is in medium and large farms. The percentage area of oilseeds on small farms is lower than that of wheat as well as gram.¹⁵²

The comparatively lower importance of oilseeds on small farms is expected in a partly commercialized agriculture. The farmer will give more area to cash crops only if his farm is big enough to spare some area from food crops.

Fodder. Because of the small size of the farms and dry conditions there are no big grazing grounds or ranches in West Pakistan. As the cattle are the suppliers of milk, meat and energy, they are an indispensable part of a farm. To feed them, the farmer has to devote some part of his farm to fodder crops. Although fodder is grown throughout the year, sixty per cent is grown as a rabi crop.

The concentration of fodder (Fig. VI-D), has some similarities to wheat. First, like wheat it is important in all the divisions. Second, just like wheat, its distribution is fairly uniform. This uniformity and evenness are indicated by the presence of only two categories of consecutive concentration range. The cultivation of fodder to some extent throughout the province is because of its bulky and perishable nature.

¹⁵²Nine per cent of wheat and eight per cent of gram is grown on small farms.

It has to be produced where it is needed.¹⁵³

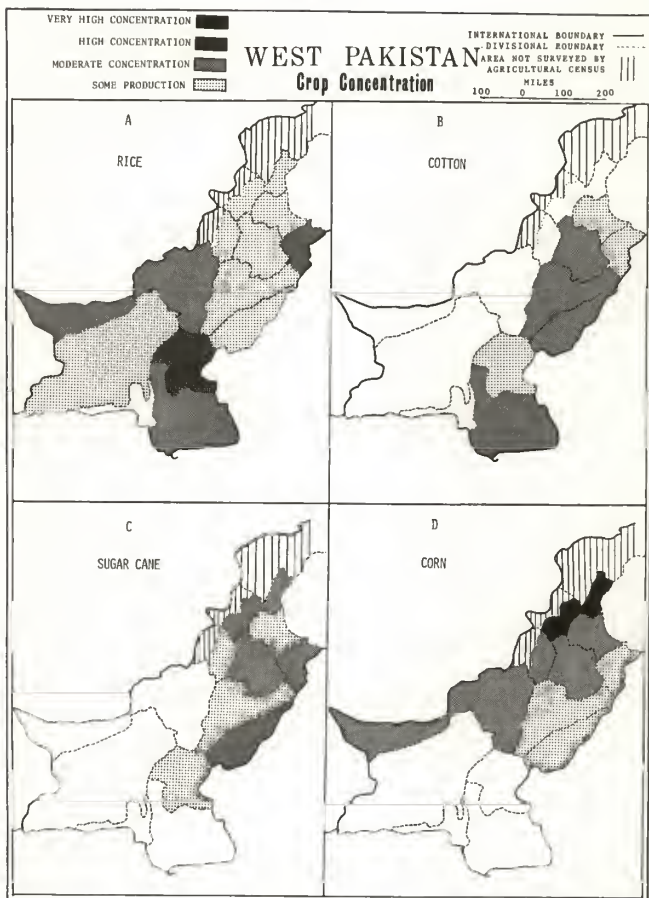
The concentration of fodder shows accordant relations with the intensity of irrigation and the size of farms. Almost all the divisions with high irrigation intensity have a higher concentration of fodder. The Lower Indus Basin is an exception which will be explained soon. The concentration of fodder over the high irrigation intensity areas is due to very high cropping intensity which leaves almost no area available for grazing or grasses. Under this condition, comparatively more area has to be given to cultivated fodder.

A comparison of the map showing concentration of fodder with that showing large farms reveals that, generally, cultivated fodder occupies a smaller area in the divisions with higher concentration of large farms. The exceptional case of the Lower Indus Basin, as mentioned above, does fit better here. The farmers with large farms do not have to devote much area to fodder because, since cultivation is less intensive, considerable areas are left without cultivation and such areas can serve as uncultivated pastures and provide grasses for livestock.

The relation between fodder and irrigation is also demonstrated by the fact that the area devoted to fodder in winter is considerably greater than that in summer. Because the summer fodder is an uneconomic user of water, the farmers produce more fodder in winter.¹⁵⁴

¹⁵³S. Z. Ahsan, "Hub Dam Project: A Geographical Analysis," Geographia, III (Winter, 1964), p. 128.

¹⁵⁴Asghar, op. cit., p. 231.



Rice. Rice, a typical monsoon crop, has been widely grown in the subcontinent since prehistoric times.¹⁵⁵ Presently, it is cultivated over about eight per cent of the total cropped area in West Pakistan. The pattern (Fig. VII-A), does not suggest a notable accordance with intensity of irrigation. However, the very high water requirement of rice indicates that, with the exception of probably the extreme north-east, rice cannot be grown without irrigation under the arid and semi-arid conditions of West Pakistan. As the precipitation is considerably higher (Fig. II) in the northeast, there are chances of growing rice without irrigation in that area. To appreciate the relation between rice cultivation and irrigation, it might be noted that in former Punjab, during the rapid extension of irrigation (1906-1947), the area under rice increased from 2.4 per cent to 6.6 per cent.¹⁵⁶

Cultivation of rice in West Pakistan is closely associated with inundation and nonperennial canals. The map showing the concentration of rice is not revealing in this respect, because some irrigation in the monsoon season is possible throughout West Pakistan. However, it was pointed out earlier that the Lower Indus Basin has comparatively more land under nonperennial irrigation, and it might be noted from the map that rice has the highest concentration in the Lower Indus Basin. Rice has been found to be suitable for nonperennial irrigation and so is the

¹⁵⁵R. C. Majumber, H. C. Raychoudhuri, and D. Kalikinkar, An Advanced History of India, Part I: Ancient India (Macmillan, London, 1955)

¹⁵⁶Malik, op. cit., p. 127.

major crop over the areas served by nonperennial canals.¹⁵⁷ Because it is a very uneconomic user of water rice is neither suitable nor economical for the perennial irrigation system in West Pakistan. In the case of nonperennial canals, water is abundant in summer and so economy of water is not necessary. Another reason for the dominance of rice in the Lower Indus Basin is the problem of waterlogging and salinity, produced by the network of canals. Rice has proved to be the most suitable crop for the areas with a high water table, where the increase in area under rice is directly proportional to the rise of water table.¹⁵⁸ Two other divisions with higher concentration of rice are Lahore and Quetta. In Lahore, due to higher precipitation, some rice is perhaps grown without irrigation. This is supported by the fact that the district with the lowest irrigation intensity in Lahore Division has the highest concentration of rice. In Quetta only one district produces rice, and that district has the highest intensity of irrigation in this division.

Cotton. Cotton is the most important cash crop of West Pakistan. It has been produced since time immemorial in the Indus Valley and is perhaps indigenous to the subcontinent.¹⁵⁹ It occupies about nine per cent of the total cropped area in the province.

¹⁵⁷C. M. Hussain, "Cropping Pattern and Irrigation Practices." Sixth NESR Regional Irrigation Practices Seminar, Amman (Washington: Stewart Mercury, 1966), p. 350.

¹⁵⁸Ibid., p. 345.

¹⁵⁹E. K. Janaki Ammal, "Introduction to the Subsistence Economy of India," Man's Role in Changing the Face of the Earth, ed. William L. Thomas (Chicago: The University of Chicago Press, 1955), p. 332.

The concentration pattern (Fig. VII-B), is closely related to the intensity of irrigation. It is clear from the maps that cotton is produced only in the divisions with a high irrigation intensity. Within the area showing a concentration of cotton, concentration indexes are highest for Multan and Bahawalpur divisions. These two divisions have the highest irrigation intensity (Fig. I). The only division with a high irrigation intensity but without cotton concentration is Khairpur. This is because of a large area under nonperennial canals. Although cotton is a summer crop, its sowing starts before the water is available in canals, and it requires water even after the canals have been closed.¹⁶⁰ Another reason for the lower concentration of cotton in Khairpur might be waterlogging.¹⁶¹ The extension of perennial irrigation is mainly responsible for the production and concentration of cotton in West Pakistan. The British policy in the subcontinent was to commercialize the agriculture, and so it encouraged crops which had commercial value in Europe.¹⁶² As cotton has been one of the most important commercial crops in British India, it is difficult to determine the cause-and-effect relationship between perennial irrigation and cotton cultivation. However, rapid extension of cotton cultivation took place during the extension of perennial canals in the Indus Valley. The construction of Sukkur Barrage,

¹⁶⁰ It was pointed out in Chapter III that in nonperennial canals water is available from April 15th to October 15th.

¹⁶¹ Programme for Waterlogging and Salinity Control in the Irrigated Areas of West Pakistan, op. cit., Plate V.

¹⁶² Aminul M. Islam, "Changes in Cropping Pattern in East Pakistan," The Oriental Geographer, XII (January, 1968), p. 13.

which brought perennial irrigation to the Lower Indus Basin, more than tripled the acreage under cotton in this area.¹⁶³ To appreciate the relation of cotton to irrigation in general and perennial irrigation in particular, it might be noted that in 1905 only 3.4 per cent of the total cropped area in former Punjab was under cotton and it increased to sixteen per cent in 1920-21.¹⁶⁴ The failure to achieve the production target for cotton and sugar cane during the Second Five Year Plan was also due to the failure to extend perennial irrigation.¹⁶⁵ It also appears that cotton is avoided in the areas with a concentration of small farms. It has already been noted that cash crops are seldom found on small farms.

Sugar cane. Sugar cane is the second important cash crop in West Pakistan. Like cotton it depends heavily upon irrigation. The map (Fig. VII-C) shows a notable accordance with intensity of irrigation. The relation is, however, not so striking as observed in the case of cotton. The reasons are perhaps the higher requirement of water and the fact that the sugar cane is cultivated by the owners of small farms as well. The production and even concentration of sugar cane in the northern part of West Pakistan should not give the impression that sugar cane is cultivated in unirrigated areas. If the districts in the northern

¹⁶³ L. H. Gulick, Jr., "Irrigation System of the Former Sind Province, West Pakistan," The Geographical Review, LIII (January, 1963), p. 32.

¹⁶⁴ Malik, op. cit., p. 126.

¹⁶⁵ Government of Pakistan Planning Commission, The Third Five Year Plan 1965-70, p. 394.

divisions of West Pakistan are considered, sugar cane is grown only in those districts which have large areas under irrigation. It might be noted that even where the amount of rainfall is adequate, irrigation is necessary to provide the proper amount of moisture at the proper time.¹⁶⁶ Due to a very high gross value of product per acre, the farmers with small farms also produce sugar cane where a dependable water supply is available.¹⁶⁷ However, since it requires a large quantity of water, it is not grown as extensively as cotton. Only three per cent of the total cropped area in West Pakistan is under sugar cane as compared to nine per cent under cotton. The relation between perennial irrigation and sugar cane is closer than that between cotton and perennial irrigation because sugar cane needs water for longer periods than does cotton. Probably for this reason it is completely absent from the Lower Indus Basin.

Corn. Corn is considered to be indigenous to America and most authorities believe that it spread from America to the rest of the world. In fact, some geographers believe that corn was introduced into the sub-continent by the Portuguese.¹⁶⁸ This belief seems to be contrary to the history as well as to the present distribution of corn in West Pakistan. The presence of a variety of corn was reported by Greek scholars at the

¹⁶⁶Van Valkenburg, op. cit., p. 129.

¹⁶⁷Faustian, op. cit., p. 117.

¹⁶⁸Van Valkenburg, op. cit., p. 127.

time they visited the Indus Valley.¹⁶⁹ At present, the areas which are notable producers of corn are along the foothills of Kashmir in north-east West Pakistan and northwest India.¹⁷⁰ It is important to note that the influence of the Portuguese remained only along the western coast of Peninsular India.

The present distribution of corn (Fig. VII-D) is related to precipitation as well as to irrigation. In the mountainous areas in the north and northwest of the province, corn is mainly produced without irrigation. On the one hand this is suggested by a higher quantity of precipitation in all the divisions which show a higher concentration of corn, and on the other by the fact that the districts which are important producers of corn in the divisions of Rawalpindi, Peshawar, Dera Ismail Khan and Quetta have either the lowest or a lower intensity of irrigation. In Dera Ismail Khan only one district produces corn and that has the lowest intensity of irrigation in the division. Rice is also cultivated without irrigation in the northeast, and it has been found that in the same submontane areas rice is replaced by corn when the slopes become steeper.¹⁷¹ As one moves away from the areas with higher precipitation, one notes moderate concentration of corn in Sargodha Division and some production in Multan and Bahawalpur. In these divisions

¹⁶⁹L. D. Stamp (ed.), A History of Land Use in Arid Regions (UNESCO, 1961), p. 111.

¹⁷⁰Janaki Ammal, op. cit., p. 331.

¹⁷¹Van Valkenburg, op. cit., p. 123.

corn is produced under irrigation because it would be impossible to grow this crop with less than ten inches of rainfall. This is supported by the fact that within Sargodha Division, almost all the corn is produced in Multan District which has the highest intensity of irrigation. An additional evidence of irrigated corn in the Northern Indus Basin is the rapid increase in the area under corn at the time of extension of irrigation. During the first half of the present century, the area under corn more than doubled.¹⁷²

Corn is totally absent from the southern divisions of West Pakistan. It is not grown in Karachi and Kalat divisions probably because of a very low intensity of irrigation. The presence of waterlogging and salinity in most of the irrigated area seems to be the factor responsible for the absence of corn in Khairpur and Hyderabad divisions. Corn is extremely sensitive and intolerant of saline soils, especially in hot and dry climates.

¹⁷²Malik, op. cit., pp. 127-28.

CONCLUSION

Irrigation is the most important factor influencing the extension and characteristics of agriculture in West Pakistan. Throughout the ages irrigation has been an expression of the need for water, the natural endowment, the level of technology, and the political conditions in this area. Before the middle of the fourteenth century, as far as definite information is available, the predominant considerations for establishing irrigation were the need and the natural endowment. After about the middle of the fourteenth century, the factors of political stability and available technology started increasing in importance. During the British period, political stability and technology, because of the technological innovations in the west and availability of capital, played a significant role in creating the world's most extensive irrigation system. Predominant economic objectives of the pre-partition rulers created the problems of waterlogging and salinity as well as of economic disparity by neglecting certain parts of present West Pakistan which were not economically attractive. After the creation of Pakistan, the process of irrigation was influenced by the problems inherited from pre-partition and those introduced with partition. Since it was not possible for this writer to do full justice to these problems, further research is suggested. A study of the immigration of refugees, in relation to irrigation agriculture, might give valuable and interesting results.

Observable correlations are found among types of irrigation, water resources, climate, waterlogging and salinity, and size of farms. The areas with moderate precipitation are suitable for well irrigation.

Limitations on surface water resources, defects of canal irrigation, and advancement in ground water engineering have increased the importance of well irrigation, while small size of farms has constituted a limiting factor in the extension of tubewells. High concentration of Persian wheels in the submontane area was a result of a higher water table, more precipitation and small farms. In general, wells are replacing canals and karez. The presence of karez irrigation is probably due to topography, a higher rate of evaporation, a feudal system, and large farms. However, further studies are suggested to understand the changes in this interesting irrigation type.

Irrigation influences the size of farms directly as well as indirectly. The direct influence is through the allotment of land, especially in newly irrigated unpopulated areas. The indirect influence is through greater productivity and consequently higher rate of population increase. This increase is observable throughout the irrigated areas but is more significant in the older settled areas. Small farms appear to be associated with the Persian wheel. Canals and tubewells favor medium farms. The large farms are associated either with no irrigation or, at best, with karez irrigation. Generally the introduction of irrigation has resulted in the reduction of farm size, and this influence has become more significant with the passage of time. The situation might become serious if further intensification of agriculture is not accomplished and the village masses are not provided with alternate occupations.

In regard to its influence upon crops, irrigation has not brought new crops, but it has encouraged changes in spatial distribution and in the relative importance of various crops. High-value crops show higher concentration in the divisions with higher irrigation intensity and especially in those with perennial water supplies. Low-value hardier crops are concentrated either on unirrigated areas or in the divisions having low intensity of irrigation. Cash crops are usually favored on medium and large farms, provided the required moisture is available.

As a whole, throughout West Pakistan, rabi crops occupy much more area than the kharif crops. This is contrary to the availability of water since water is abundant in summer but scarce in winter. Three factors appear to be responsible for this: (1) water is used more efficiently in winter, primarily due to lower evapotranspiration; (2) crops grown during winter (rabi) are more valuable in terms of water and labor input; and (3) since water supplies are controlled by the government, the farmers can irrigate only after a fixed interval of time regardless of crop requirements.¹⁷³ Under the above mentioned conditions, the farmers do not take the risk of a higher investment in high-value sensitive crops. Besides, the traditional conservatism of the cultivator is also a hindrance in developing an optimum cropping pattern and in switching to the crops which pay more.¹⁷⁴

¹⁷³Michel, op. cit., p. 117.

¹⁷⁴Calvert, op. cit., p. 209.

However, the situation is changing, probably because of dependable and secure water supplies. It was observed that the high-value sensitive kharif crops show considerable concentration in the irrigated areas of the divisions with higher irrigation intensity. A comparison of Table II with the map (Fig. I), further clarifies this point. The table shows the percentage of total cropped area devoted to rabi and kharif crops for each division. Included under kharif crops are sugar cane, cotton, rice and corn; rabi crops included are wheat, oilseeds, and gram.

There is a direct relationship between the intensity of irrigation and the percentage of kharif crops, while an inverse relationship exists between intensity of irrigation and rabi crops. The only division which does not follow this general trend is Peshawar where, in spite of the lower irrigation intensity, the percentage of cropped area under kharif crops is comparatively high. The reason for this, as indicated earlier, is probably extremely high concentration of corn in this division. Corn in Peshawar accounts for twenty-six per cent of the total cropped area as compared to three per cent in West Pakistan. This high concentration (concentration index - 8.66) cannot be explained with reference to irrigation or to any other factor considered in this work. Since the significance of this unusually high concentration of corn is not interpreted by the writer, further research is suggested in this area.

TABLE II

DISTRIBUTION OF RABI AND KHARIF CROPS IN WEST PAKISTAN

Division	Percentage of cropped area	
	Rabi crops	Kharif crops
Karachi	100	0
Kalat	96	4
Dera Ismail Khan	94	6
Rawalpindi	86	14
Quetta	77	23
Sargodha	75	25
Multan	66	34
Bahawalpur	66	34
Khairpur	59	41
Lahore	58	42
Peshawar	66	44
Hyderabad	39	61

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THE ROLE OF IRRIGATION IN AGRICULTURE
IN WEST PAKISTAN

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AN ABSTRACT OF A MASTER'S THESIS

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The purpose of this thesis was to examine the role irrigation has played in the agriculture of West Pakistan. Data and information were gathered from a long list of references. However, the most valuable source was the 1960 Pakistan Census of Agriculture.

Correlations were found between the characteristics of irrigation, types of irrigation, size and distribution of farms, and types of crops and their relative importance. Small and medium farms were strongly associated with irrigation. The relation between well irrigation and small farms was so close that the cause and effect relationship could not be determined. Although the medium farms were relatively uniformly distributed, they showed a higher degree of concentration on land newly put under canal irrigation. In general, small and medium farms did not show the same degree of concentration in the same area because both of them were associated with irrigated areas. However, small farms showed relatively higher concentration in old irrigated divisions, while medium farms showed higher concentration in newly irrigated divisions. Distribution patterns of large farms were different from those of the medium as well as small farms. The distribution of large farms was relatively uneven; they were highly concentrated in unirrigated parts of the divisions with low irrigation intensity. The location and concentration of the types of farms were found to be influenced by government policies, laws of inheritance, and the deficiency of alternate occupations for the rural population.

In the case of crops, although wheat was found to be widely cultivated throughout the province, it showed higher concentration in the

areas with lower irrigation intensity and larger farms. Being the most popular food crop and having a hardy nature, it was found to be preferred on all types of farms in irrigated as well as unirrigated areas. The distribution of gram and oilseeds showed some similarities with that of wheat, but these two crops were more important on larger farms and irrigated land. Fodder was more or less evenly distributed with slightly higher concentration in the areas where farms were smaller and irrigation intensity was higher. Rice did not show much relationship to intensity of irrigation, but its concentration was observed in the areas under nonperennial water supplies. Corn was found to be more unevenly distributed than any other crop grown in West Pakistan. Irrigation intensity did not appear to influence the concentration of corn. It is cultivated in irrigated as well as unirrigated areas. The distribution and concentration of cotton and sugar cane were strongly associated with irrigation. The relationship between these two crops and perennial irrigation was particularly significant. Concentration of cotton was higher on medium and large farms while sugar cane appeared to be preferred on small and medium farms. As a whole the higher irrigation intensity and secure water supply were found to be in favor of high-value kharif crops.