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SOME GEOGRAPHICAL ASPECTS OF THE INDUS WATERS TREATY AND DEVELOPMENT OF IRRIGATION IN WEST PAKISTAN

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West Pakistan is an arid or semi arid country with mountains in the north and the west. A little less than half consists of a flat plain drained by the Indus and its tributaries, (the combined waters of which fall into the Indus about half way from the mountains to the sea.) While the upper part of the Indus basin lies in the Himalayan region, the middle and the lower parts lying in the plain consist partly of prosperous irrigated land and partly of desert. Out of a total area of 198.7 million acres in West Pakistan, 102.5 million acres comprise rugged mountainous terrain, the remaining 96.2 million acres consist of deserts and flat aggradational plains. The Indus basin, which spreads over both these regions, has an area of 138.7 million acres. Of the portion which constitutes the plain, only about 66.6 million acres are good agricultural land. Due to a general paucity of rainfall, the economy of the plain is based on an elaborate system of irrigation which has been built largely during a century of the British rule and which is one of the best in the world. About 42 million acres are now under cultivation in West Pakistan, of which some 32.8 million acres are under the command of about 38 thousand miles of canals.[1] The remaining 9.2 million acres depend upon rainfall for cultivation. Actually, on the average, 24 million acres[2] are irrigated every year in the principal canal systems, slightly more in the *Rabi* (winter) season than in the *Kharif* (summer) season. For the purpose of water resources evaluation and their effect on land use, West Pakistan may be divided into two regions, northern and southern, roughly along the old boundary of the former provinces of Punjab and Sind in the plains, and along the divide between the rivers flowing into the Persian Gulf and those

1. The gross area is 36.8 million acres—22.3 million acres in the Upper Indus Plain and 14.5 in the Lower Indus Plain.

2. This is about 12% of the irrigated area of the world. In comparison with it, the total irrigated area of the Nile valley is just over 6 million acres and in U.S.A. about 7 million acres.

flowing into the Indus in the mountain region in the north of Baluchistan. Along the same boundary the Indus plain may also be divided into two parts, Upper and Lower. A subterranean ridge underneath the plain near the boundary also separates the two parts, which differ not only climatically but also in the problems of surface water supply and ground water.

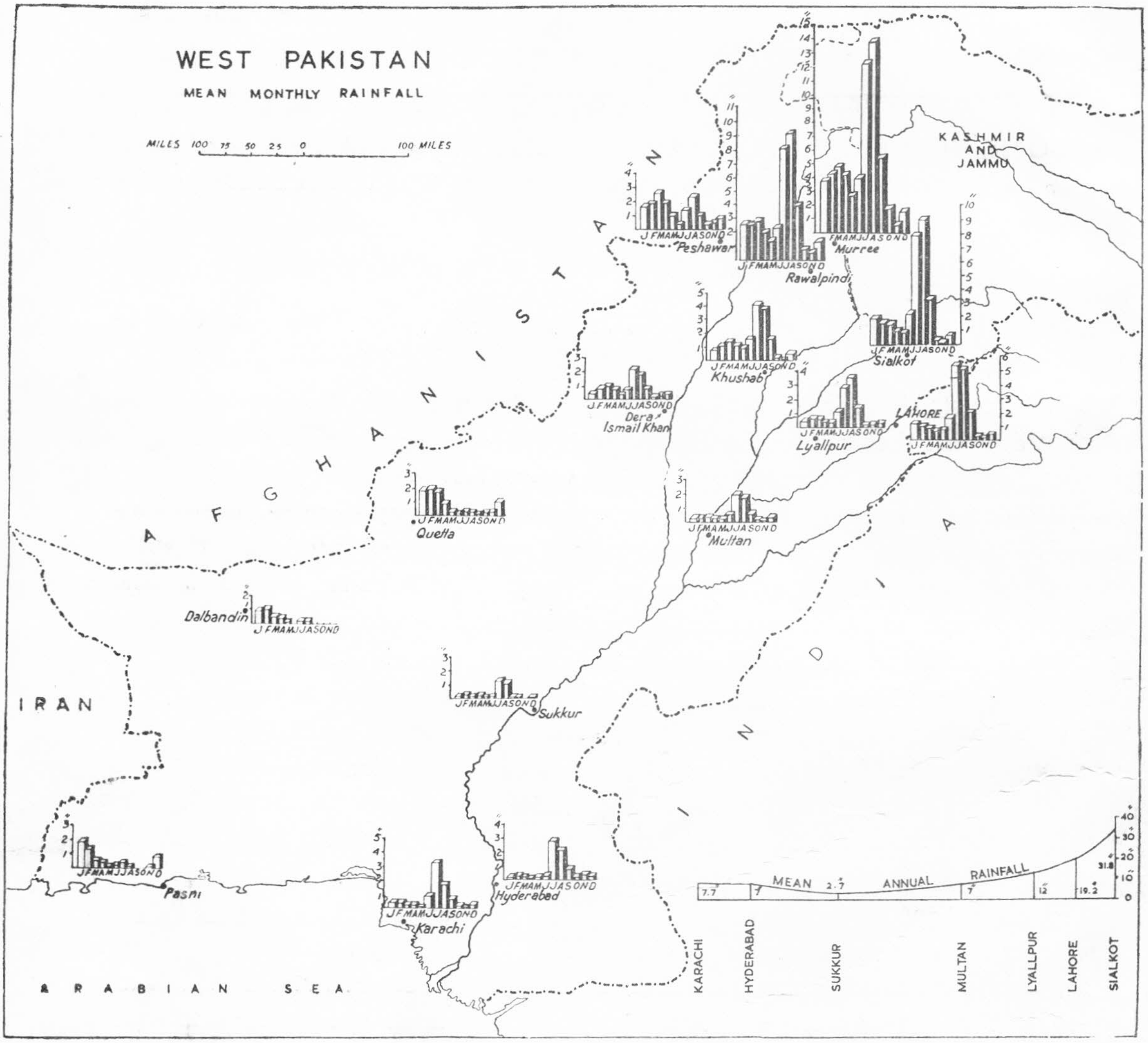


Fig 1

Water Resources

Before discussing the Indus Waters Treaty, it will be useful to make a brief appraisal of the water resources of the basin.

Rainfall

Excepting a narrow submontane strip in the north, the rainfall is generally low in the

Indus plain and rapidly decreases from the Himalayas toward the south. The mean annual rainfall of Sialkot at the foot of the Himalayas is 31.8″, Lahore 19.2″, Lyallpur 12″, Multan 7″, Sukkur 2.7″, Hyderabad 7″, Karachi 7.7.″ (Fig. 1). It drops to less than 5″ in a large area below the junction of the Panjnad with the Indus. In more than 60 per cent of the cultivable area, the rainfall is less than 10″ and, therefore, irrigation is necessary for agriculture. The rainfall variations though of little value in the Lower Indus plain are quite important in the Upper Indus plain.

More than half to three quarters of the rainfall is obtained in the late summer from the monsoons, July and August being the months of highest rainfall in all the stations mentioned above. The variations in rainfall therefore become a significant factor in flood irrigation.

Surface Flow or Runoff

The following table gives the hydrological data of the rivers of the Indus Plain as given by Burrard and Hayden.[1]

TABLE 1

HYDROLOGICAL DATA OF THE INDUS PLAIN RIVERS

River	Mean annual rainfall in the catchments	Percentage of rainfall run-off	Runoff in acre feet in thousands	Total discharge of water in one year[2]
Indus	17.74	77.98	87,355	9.0
Jhelum	42.33	84.93	23,860	5.5
Chenab	47.24	81.06	23,277	5.5
Ravi	39.00	40.89	6,541	1.0
Sutlej	19.71	56.67	13,938	3.5
Beas	56.50	77.34	12,546	2.5
Total ..	..	..	167,517	..

It is not very different from the average of the decennium 1937-46 immediately before partition or for the 40 years 1922-1961 as given below. It is graphically shown in Figure 2. (*a*) and (*b*)

1. S.G. Burrard and H.H. Hayden, *A sketch of the Geography and Geology of the Himalaya Mountains and Tibet*, Delhi. Manager of Publications, 1934.

2. Taking the Ravi discharge as unit, based on short observations and rough estimates.

TABLE 2[1]

Group	River	Station	Average Annual Rainfall Million Acre Feet			
			1937—1946		1922—1961	
Eastern	Ravi	Madhopur	6		7	
	Beas	Mandi Plain	13		13	
	Sutlej	Rupar	14	33	34	34
Western	Indus	Attock	89		93	
	Jhelum	Mangla	23		23	
	Chenab	Marala	23	135	26	142
		Total : ..		168		176

It will be seen that the average flow of the Indus is greater than the total of the other rivers, while that of the three western rivers, Indus, Jhelum and Chenab, is about 80 percent of the total flow. In respect of the three western rivers, the flow of the Indus alone is about two-thirds of the total.

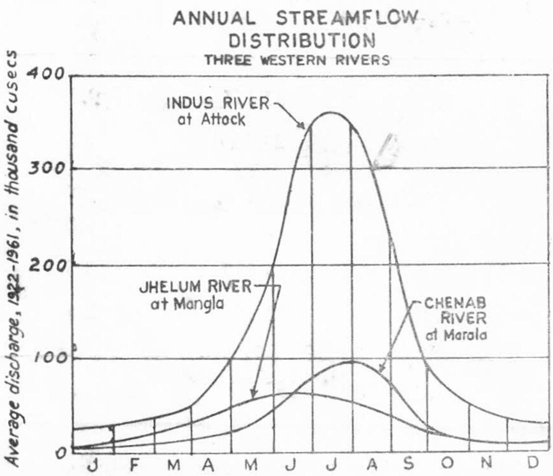
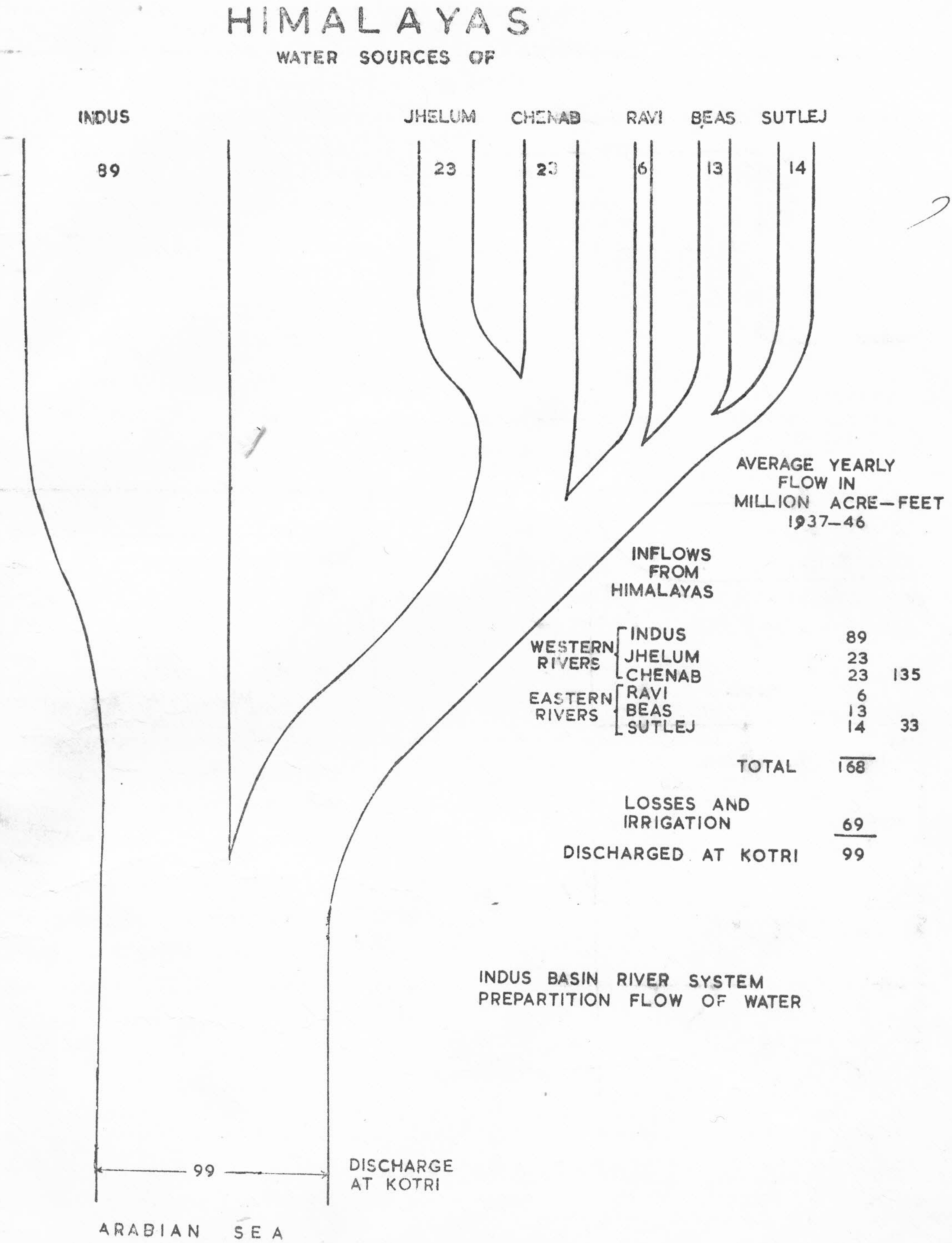


Fig. 3

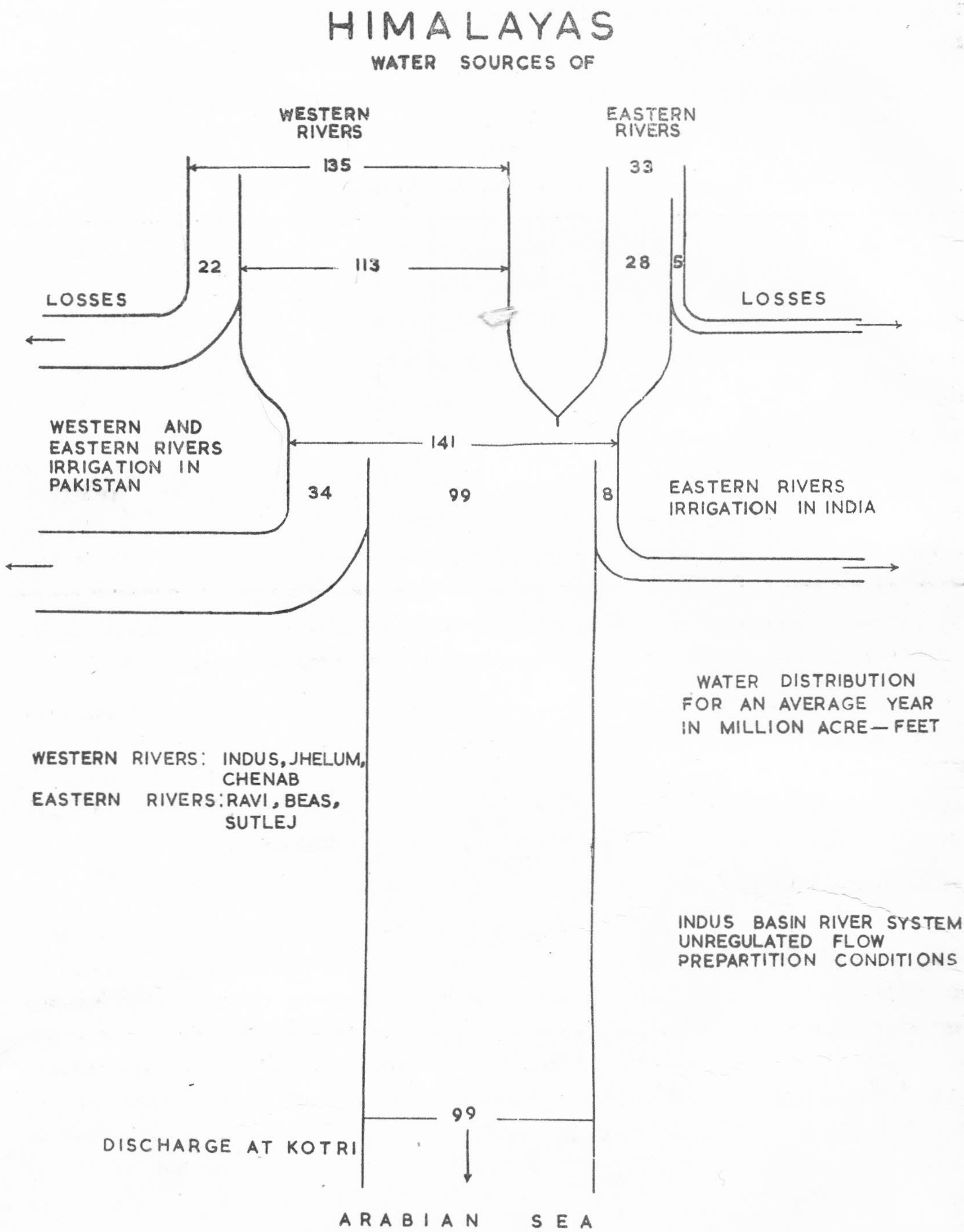
The rivers show great fluctuations in their flow during the course of the year. The discharges are generally low from September/October, the end o summer monsoon, to March/April when the snow begins to melt. The high flow discharges in summer are bout 50 to 100 times larger than the minimum winter discharges. Figure 3 gives the monthly flow of the three western rivers. While the flow in the Indus and the Chenab show similar trends, conspicuously high peaks in July and August, that of the Jhelum is much smoother. Its peak is much lower and occurs earlier, extending over the three months May to July. This is obviously due to the fact that it flows through a great lake, the Wular, and therefore

1. Programme for Water and Power Development in West Pakistan Supporting Studies : A Report by Harza Engineering Co. for WAPDA, Lahore, 1963, p. 1—12.



From: *Indus*, Vol. 2, No. 4, May, 1961.

Fig 2. (*a*)



From : *Indus*, Vol. 2, No. 4, May, 1961.

Fig. 2 (*b*)

its waters are naturaly regulated. Even after the Mangla Dam is constructed the Wular lake will continue to function as a second reservoir.

The following table shows the maximum flood discharges for Indus Plain rivers.[1].

TABLE 3

MAXIMUM FLOOD DISCHARGES

River	Location	Date	Cusecs
Indus	Attock	August 1929	820,000
Indus	Sukkur	Aug. 1958	1,100,000
Jhelum	Mangla	August 1929	1,043,000
Chenab	Marala	July 1959	871,000
Ravi	Shadara	October 1955	542,000
Sutlej	Suleimanki	October 1955	422,000
Panjnad	Punjnad	September 1950	677,000

It will be seen that a tremendous quantity of water goes waste. The Indus carries not only the greatest amount of flow but also the maximum flood discharges.

The flow regime of the Jhelum suggests the possibility of creating natural reservoirs in the form of lakes at suitable points in the upper courses of the Indus and the Chenab. With a more regulated flow, the cost of the Tarbela dam on the Indus is likely to be considerably reduced, and technically the project may be more feasible. It may also, to some extent, even out the effects of the variations of rainfall from year to year.

Ground Water Reservoir

Investigations have shown that virtually the entire Upper Indus Plain is underlain to depths of 1000 ft. or more by unconsolidated alluvial sediments which are saturated by groundwater to within a few feet of the land surface. The texture of these sediments is not uniform, but it is estimated that high capacity wells can be developed practically on any site. It is shown that the alluvium beneath 60 percent of the Bari doab (4.4 million acres), 85 percent of Rechna doab (4.7 million acres), 80 percent of Chaj doab (2 million acres), and 72 percent of Thal doab (5.3 million acres) is saturated with fresh water suitable for irrigation. It is estimated that there are 500 million acre feet of water stored in each hundred feet of depth in the Upper Indus plain. The reservoir can yield 1900 MAF of fresh water, which is equal to 10 times the yearly average discharge of the entire Indus Plain, and probably is

1. Wapda, Programme for Water and Power Development in West Pakistan through 1975 (Master Plan-Initial Phase) A Report by Harza Engg. Co. Int. 1964, p. 45.

more than the total quantity of water that will be available from both Mangla and Tarbela dams.[1]

It is estimated that approximately one-third of the irrigation water diverted from the main rivers percolates into the underground aquifers of the plain. The total amount of percolation from various sources—rivers, canal, farms and rainfall—amounts to about 36.4 MAF, about 22 MAF in Upper Indus Plain and 14 MAF in the Lower. On account of the flatness of the country, all this amount cannot drain away as quickly as it is added with the result that the ground water reservoir is increasing and the water table is rising. Under the Upper Indus plain there is a concealed extension of the Peninsular block on which lies the sub-terranean Delhi-Sargodha ridge. It serves as an underground dam preventing the flow of water to the southwest. This accounts for the abundance of ground water to the northeast of the ridge and the lower water table to the southwest.

The possibilities for finding appreciable supplies of suitable water from beneath the Lower Indus plain are relatively small. There are indications that most of the ground water, except for land within about 3 to 15 miles of the Indus, is too saline for irrigation purposes.

Indus Waters Treaty

On the partition of the sub-continent in August, 1947, the unified system of irrigation under one control was split between Pakistan and India. The boundary was unfortunately so drawn that the headworks on the two rivers Sutlej and Ravi went to India while most of the area commanded by canals from these rivers came to the share of Pakistan, thereby necessitating Pakistan to depend on water over which she had no control. The head streams and the upper courses of the other two rivers, Chenab and Jhelum, which flow into West Pakistn are in Kashmir which soon after the partition provisionally acceded to India.

On the first of April, 1948 one day after the Arbitral Tribunal instituted for settling disputes arising out of the partition ceased to exist, India stopped irrigation supplies from Sutlej, Beas, and Ravi to all canals crossing into Pakistan. A serious dispute thus arose for the distribution of their waters. After long negotiations, the dispute was eventually resolved through the mediation of the World Bank by a treaty between the two countries signed on the 19th of September 1960, commonly known as the Indus Waters Treaty. It provides that India will be entitled to the unrestricted use of the waters of the three eastern rivers (Sutlej, Beas and Ravi). Pakistan will be entitled to the use of the three western rivers (Indus, Jehlum and Chenab), except for certain uses specified in the treaty for areas lying in India and Jammu and Kashmir. The Treaty also specifically provides that India will not construct any storage works on the western rivers except for uses mentioned above. The settlement plan for Pakistan includes the construction of two storage dams at Mangla and Tarbela, seven link canals, four barrages, and one gated syphon along with the remodel-

1. Wapda Miscellany, Lahore 1962 p. 10.

ling of existing link canals and some irrigation systems severed by the new construction (Fig. 4).

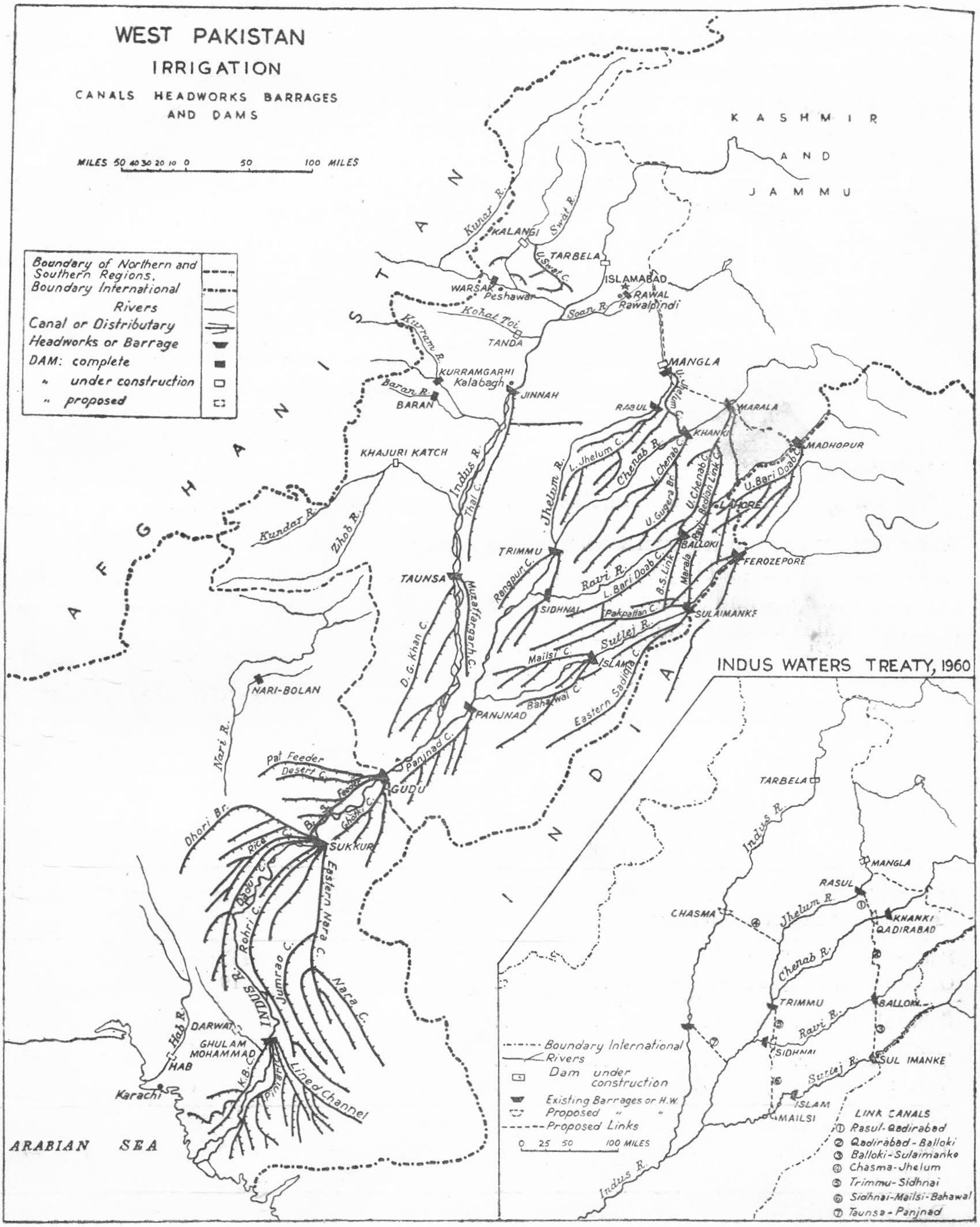


Fig. 4

Along with the Treaty there has been set up the Indus Basin Fund; and there were made international agreements to finance the replacement works, including the Indus Basin Development Fund Agreement.

The total expenditure has been estimated to be about 900 crores of rupees. Starting in 1960, the works under the treaty are scheduled to be completed by 1970 and will constitute the biggest water development project ever undertaken at any one time in the history of the world. An important provision of the treaty is that during the next ten years (1st April, 1960—31st March, 1970) the diversion of waters to India will be made gradually to enable Pakistan to complete the works to replenish the water allocated to India. During this transition period, Pakistan will have unrestricted use of water of the eastern rivers.

The primary function of the Indus Basin Project is to reestablish the normal river flows of the Sutlej and the Ravi, replacing the water diverted to India for the irrigation of areas (in Pakistan) presently dependent upon eastern rivers. It will mean the transfer of approximately 24 MAF from the western rivers through the new link canals.

But the project has to be considered as part of the development of water supplies of the whole Indus plain to provide for the rapidly increasing population's needs in respect of food and industrial raw materials. During the decade 1951—61 the population has increased by 2.4 percent and it is estimated that the population will be increasing by 2.6 to 3 percent, which will mean about another 15 million people to provide for.

Water Supply and the Implementation of the Treaty

The following table gives the average annual conditions of water supply before partition, after the implementation of the Treaty and after additional water from storage reservoir is and tubewell water is provided.

TABLE 4[1]

AVERAGE ANNUAL CONDITIONS OF EASTERN AND WESTERN RIVERS (MILLION ACRE FEET)

	INDIA Eastern Rivers		Pakistan Western Rivers		
	Before Partion	After Implementation of Treaty	Before Partition	After Implemetation of Treaty	After Increase Storage Capacity
Storage Capacity	None	16.5	None	9.5	88.9
Ratio Storage Capacity to Inflow	0%	50%	0%	6.5%	61%
Inflow from Himalayas	33	33	135	135	135
Outside of Himalayas and rains			10	10	10
Subtotal					145
Tubewells					15
Total:	33	33	145	145	160
Irrigation	8	28	41	42	122
Losses	5	3	25	27	27
Discharged into the Arabian Sea via Indus River	20	None	79	76	11
Drainage Canals					24

1. Karpor and Nebolsin, "West Pakistan and Indus Valley". *Indus*, Lahore, Vol. 5, No. 1, Feb, 1964, p. 27.

It will be seen that while India will utilize all the 28 million acre feet of water available in the Eastern rivers after the implementation of the Treaty,[1] Pakistan will still be losing to the sea 76 MAF till the two dams are constructed. Losing 24 MAF to India it will have to be content with the unregulated flow that could be diverted from western rivers which will be considerably reduced during winter. It will seriously impair the productivity of the irrigated cropped lands in this region. It is estimated that the diversion of waters to India will take about 5 million acres out of irrigation in Pakistan and turn that area to desert again unless alternative sources of irrigation are found.

Present surface Water Supply and Use of Water

Unlike West European countries and some other parts of the world, the prodominant use of river waters in Pakistan is their diversion to the irrigated areas. At present the surface water supply is estimated to be 164.5 MAF (Fig. 5). Of this amount, 51 percent is being diverted into the canal systems, about 12 percent is lost through evaporation and seepage along the main river channels, and the remaining 37 percent passes into the sea.

Of the total diversions of 83.5 MAF for irrigation purposes, 48.2 MAF takes place in the Upper Indus plain—19.8 MAF in the low flow season from October to April, which approximately corresponds with the *Rabi* season, and 28.4 MAF in the high flow season, from May to September, which approximately corresponds with the *Kharif* season.[2]

In the Lower Indus Plain the total diversion is about 35.3 MAF, 11.4 from October to April and 23.9 from May to September.[3] The total diversions of the river flows for irrigation use thus now average about 52.3 MAF in the high flow season and 31.2 MAF in the low flow season. These are generally limited in the former by the capacity of the canal systems and in the latter by the available water supply.

Within the plains the lands are generally under-irrigated. In each of the two crop seasons, about 12 million acres are at present under irrigation. Farm deliveries of surface water in the Upper Indus plain are estimated at 2.2 acre feet per cropped acre during the months May to September and 1.6 acre feet from October to April. For adequate water supply they should be 2.7 acre feet and 2.4 acre feet respectively. The present water use in the Lower Indus plain is simiarly deficient.

Present Water Balance

The present water balance in the Indus Plain is given in the following table[4] and is shown graphically in Fig. 5.

1. Before partition four million acres feet were already being used in the territory now in India.
2. Master Plan, op. cit., p. 39.
3. *Ibid.*, p. 40.
4. *Ibid.*

TABLE 5

PRESENT WATER BALANCE IN THE I-ND-US PLAINS

	MAF PER Year
River Balance	
Total Surface Water Supply	164·5
Net percolation to ground water	4·0
Other losses	16·1
Flow to Arabian Sea	60·9
Total Surface Water (Diversion	83·5
Canal Balance (including Water Courses)	
Total Surface Water Diversion	83·5
Pumped from ground water	2·0
Evaporation lesses	8·0
Percolation to ground water	23·0
Total Farm Delivery	54·5
	MAF Per year
Farm Irrigation Balance	
Total Farm Delivery	54·5
Surface loss	5·4
Percolation to ground water	8·2
Net Crop Use	40·9

Of the 164.6 MAF of surface water available in the Indus and its tributaries, only about 40.9 MAF goes for non-crop use—24.2 MAF in the Upper Indus plain and 16.7 MAF in the Lower Indus plain. 20.1 MAF are lost in evaporation and percolation during diversion from the rivers to the canals, 31 MAF in evaporation and percolation during diversion from the canals to the farms and 13.36 MAF on the farms—64.7 MAF in all. Against this amount, only 2 MAF are recouped by pumping, while 60.9 MAF flow to the sea.

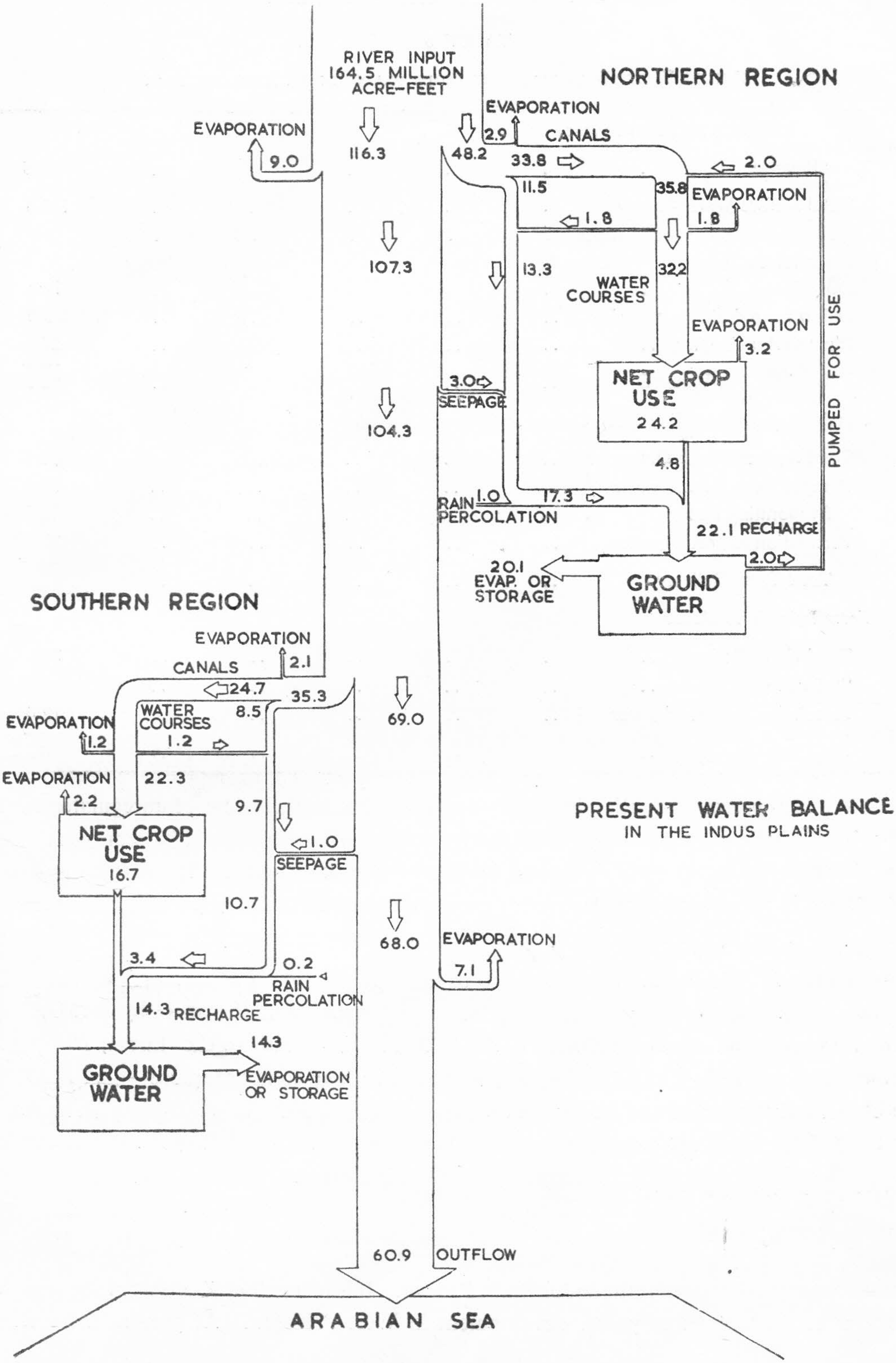
Future Surface Water Supply

After the full diversion of water of the eastern rivers to India, it is estimated that the total surface water supply by 1975 will reach 140 MAF. From this amount 92.1 MAF will be diverted into the canals and water courses, 61.0 in the Upper Indus plain and 31.1 in the Lower Indus plain. The divirsions in the Upper Indus plain will comprise 25.2 MAF in the *Rabi* and 35.8 MAF in the *Kharif* while in the Lower Indus plain diversion will total 7.7 MAF IN *Rabi* and 23.4 in *Kharif.*

Future Use of Water and Water Balance

The following table gives the water balance in the Indus Plain in 1975.[1] It is diagramatically represented in Fig. 6.

1. Master Plan, *op. cit.*, p. 55



From ; Master Plan, P. 41.

Fig. 5

TABLE 6

FUTURE WATER BALANCE IN THE INDUS PLAINS IN AN AVERAGE YEAR

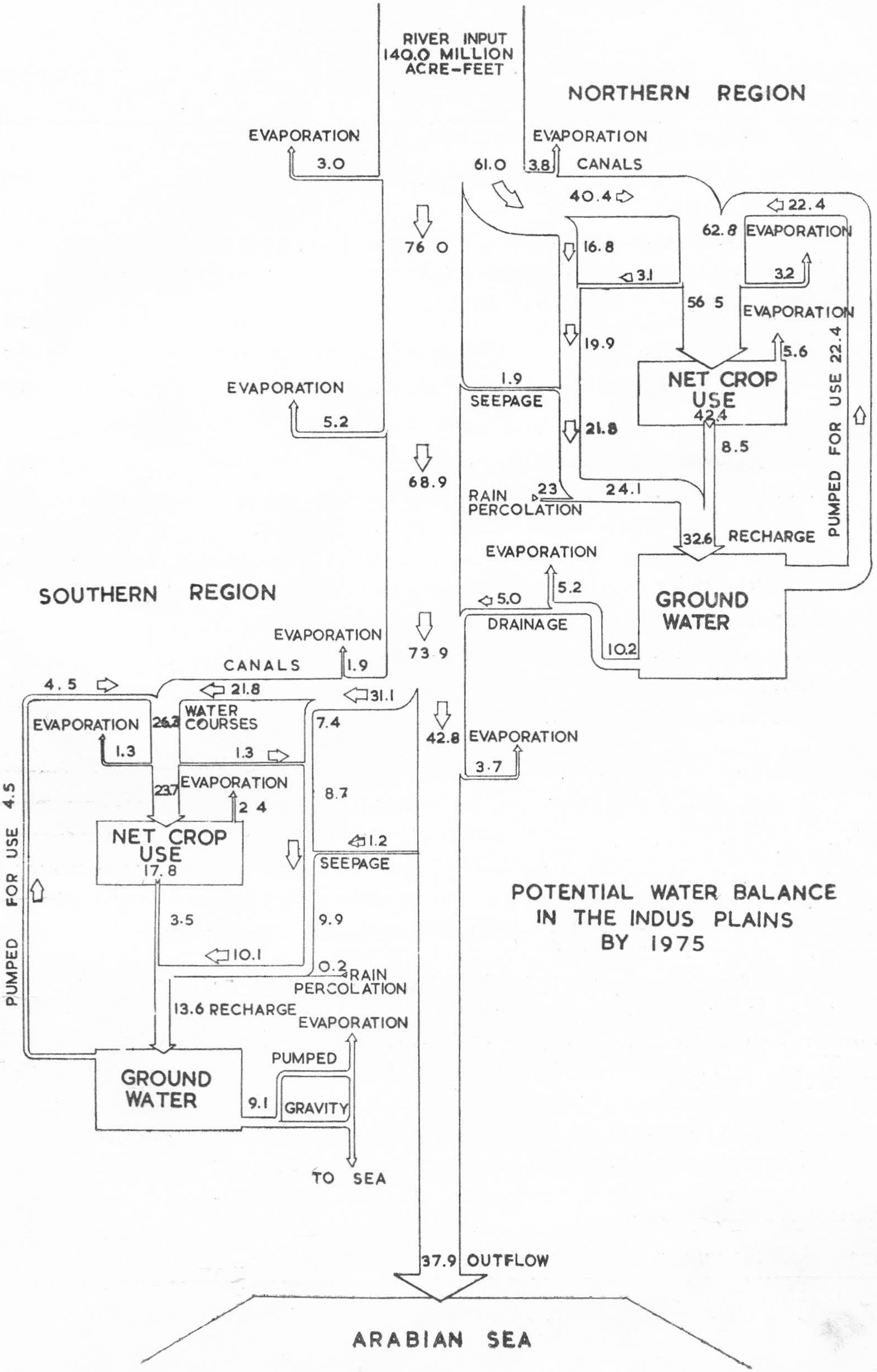
Million Acre Feet per year	
River Balance	1975
Total surface Water Supply	140·0
Net percolation to ground water	3·1
Other losses Other losses Other losses	
Other losses	11·9
Inflow from drainage pumping	5·0
Flow to Arabian Sea	27·9
Total Surface-Water Diversion	92·1
Canal Balance (including Link Canals andWater Courses)	
Total Surface Water Diverstion	92·1
Pumped from ground water	26·9
Evaporation losses	10·2
Percolation to ground water	28·6
Total Farm Delivery	80·2
Farm Irrigation Balance	
Total Farm Delivery	80·2
Surface losses	8·0
Percolation to ground water	12·0
Net Crop Use	60·2

While at present irrigation is entirely dependent on the diversions of unregulated river flows, by 1975 the supply of water from the river flows will be increased by storage release from the Mangla and Tarbela dams and by pumping ground water. The percolation and other losses in the diversion to the canals are expected to be 15 percent which will be compensated to the extent of 5 percent by inflow from drainage and pumping.

Of the 92./MAF (65.8%) diverted to canals, evaporation and percolation losses will amount to 38.8 MAF (42.1% of the diverted water), which will be offset by 26 MAF by pumping from ground water. Of the 80.2 MAF thus delivered to the farms, 20 MAF (about 25%) will be lost in delivering and 60.2 MAF will go to net crop use—42.4 MAF in the Upper Indus plain and 17.8 MAF in the Lower Indus plain. This will mean an increase of about 75 percent over the present supply in the former and of about 6.6 percent in the later. 37.9 MAF (27 percent of the total supply) will flow to the sea.

Surface Water Development

The development of surface waters will in the main consist of the Settlement Plan works constructed as part of the Indus Basin Project. It is being done as a part of the general programme for water and power development in West Pakistan. At present the surface



From : Master Plan, P. 56.

Fig. 6

waters are utilised during their natural flow. They are not controlled by stroage reservoir except for minor storage of less than 0.3 MAF. For the maximum utilisation of the surface waters, reservoirs are to be constructed and the canals are to be remodelled to carry a larger volume of water during *Kharif* and to provide for an increase in irrigation intensities.

The canals are to be lined with suitable material to prevent the loss from percolation and seepage. It is estimated that surface storage requirements for the irrigation of the Indus plains will ultimately be in the range of 20 to 30 MAF.

With ultimate development, the average annual diversions from the rivers are expected to be 40 MAF in the *Rabi* and 80 MAF in the *Kharif* season, or about 87% of the total water supply.[1]

Mangla and Tarbela dams of the Indus Basin Project will finally provide useful storage of 7.7. MAF and 9.3 MAF when they are raised further after the completion of initial phases. These dams, in addition to storing water for irrigation, will reduce the flood peak of the Indus and the Jhelum rivers. Besides these two there will be smaller reservoirs on the tributaries of the major rivers which will have a collective storage capacity of 4 MAF. It will increase the total storage capacity to 21 MAF. About 390 canals will transfer water from the western rivers to replace the water diverted by India. Investigations have shown that exclusive of Mangla and Tarbela dams there are potential reservoirs with a total quantity of some 60 MAF within West Pakistan.

After the Tarbela and Mangla dams are completed, a large volume of water (about 37.8 MAF) will still be flowing to the Arabian sea. Thus, additional water supplies can be obtained by diverting the unused flows into temporary lakes along the course of the Indus in the adjacent Thal and Thar deserts. It will help in reclaiming these dry areas by improving irrigation and fertilizing the soil and inturn, will also reduce soil erosion and encourage afforestation. It so happens that in both these desert areas depressions exist which can drain off large quantities of water from the Indus. In the Thal region, there are old channels now abandoned by the Indus and many other suitable depressions between the sand-dunes. In the Lower Indus plain, a long depression has been pointed out by Oldham[2] which runs from Khairpur to Umar Kot in Tharparkar and is partly occupied by Eastern Nara canal.

Ground Water Development

The great reservoir of ground water is expected to be another very important source of irrigation water in the irrigated area of the Indus plain. It will be needed not only to supplement the water supply in the areas commanded by canals but also to develop other areas lying outside the canal zone. Ground water reserves are also important as a buffer to tide

1. Master Plan *op. cit.*, p. 43
2. R. D. Oldham, *A Mannual of the Geology of India*, Calcutta, 1893.

over dry periods when a deficiency of surface waters occurs. It is estimated that about 36.4 MAF are added to it annually, 22 MAF in the Upper Indus plain and 14 MAF in the Lower Indus plain as given below[1] :—

Percolation	from rivers	.. .. ..	4.0 MAF
	from canals	.. .. ..	23.0 "
	from farms	.. ..	8.2 "
	from rainfall	.. .. ..	1.2 "
	Total :	..	36.4 MAF

But all the ground water is not usable for irrigation because of high salinity in many areas. Salinity concentrations vary from a low acceptiable ratio of 500 parts per million in the Upper Indus plain to an intolerably high ratio of 3000 PPM in some parts of Sind. In general ground water containing 2000 to 3000 PPM can be used in irrigation if supplemented with fresh water. Some 28 million acres, or 80 percent of the Upper Indus Plain, have ground water salinity concentration of less than 3000 PPM. About 18.6 million acres (or 56 percent of the 33 million acres lying over the ground water reservoir) are included in the culturable commanded area of the canal system.[2] Experiments have shown that large capacity tubewells, yielding 4 cusecs or more, can be developed at practically any location in the Upper Indus Plain.

Not much detailed information is available for the Lower Indus Plain where the ground water over a large area is highly saline. But it is estimated that at least 5 MAF of fresh ground water can be developed annually by tubewells for irrigation use in a strip 3 to 15 miles wide on each side of the Indus between Gudu and Ghulam Muhammad Barrages.

It is planned to construct about 34,000 tubewells by 1975, of which about 2500 are to be financed as part of the Indus Basin Project. Of the total about 29,000 wells will serve for irrigation, adding some 24 MAF to the water supply in the irrigated farms.

Extension of canal irrigation in future will lead to greater percolation and further development of the ground water reservoir. By 1975 the ground water balance is expected to be[3]

Percolation	from rivers	.. .. ..	3.1 MAF
	canals	.. .. ..	28.6 "
	farms ..	.. .. ..	12.0 "
	rainfall ..	.. .. ..	2.5 "
	Total :	..	46.2 "

1. Master Plan *op. cit.*, p. 4.
2. Supporting Studies, *op. cit.*, p. 11—35.
3. Master Plan, *op. cit.* p. 55.

Pumped to irrigation ..	..	..	.. 26.9	M.A.F
Pumped for drainage to river	..	..	.. 5.0	"
Balance	..	..	.. 14.3	"

However it may not be forgotten that tubewell water cannot compare with surface water in quality. It does add some salt to the soil, small as it may be, and its cumulative effect during the course of years may be quite damaging. So tubewells may only serve a useful purpose for short periods. Much will depend upon subsurface formations and the depth from which water is drawn. While deep wells may be constructed for irrigation purposes, drawing water from lower aquifers, shallow tubewells may be made for drainage purposes to lower and control the water table, to leach the soils and to remove salts from the root zone.

Potential Water Supplies and Requirements :

Under the programme[1] for development prepared for WAPDA, it has been assumed that in future lands already sanctioned for perennial water service and other commanded lands underlain by usable ground water would receive water supplies adequate for irrigation of 90 percent of the commanded land during the *Rabi* season and 60 percent of the commanded land during the *Kharif* season. This means that half of the cultivable land would produce two crops a year or would be used by perennial crops requiring water during all months of the year. In the Lower Indus Plain, in the non-perennial irrigated area underlain by unusable ground water, there is expected to be irrigation intensity of 90 percent during the *Kharif* season (80 percent for rice and 10 percent for other crops) and no irrigation in the *Rabi* season.

On the basis of the assumption that all the culturable land (32.8 million acre) sanctioned for irrigation would be provided with a perennial water supply for an average irrigated intensity of 150 percent and the maximum amount of usable ground water would be used for irrigation, the requirement of the surface water at the heads of canals is estimated to be 158 MAF, which is appreciably greater than the water supply that can be developed from the three western rivers.[2] As pointed out above, the potential water supply by 1975 will be about 80 MAF including 26.9 MAF from ground water.

It is considered most unlikely that ultimate development of the three western rivers by surface storage and artificial recharge of the aquifer will permit the delivery of more than 120 million acre ft. to canal heads in the plains. This quantity of water will suffice for the irrigation of 35 to 40 million acres of cropped area annually. Such an acreage can be

1. Supporting Studies of Master Plan *op. cit.*
2. Supporting Studies *op. cit.*, pp. 11-33.

obtained by the irrigation of 24 to 30 million acres of culturable land at cropping intensities that will produce optimum returns and permit control of soil salinisation.[1]

In any estimate of potential water requirements, it should be kept in view that Pakistan is a developing country. More and more water will be required not only for irrigation but also for its growing industry and municipal and domestic consumption. With the increasing pace of urbanisation and a rise in the standard of living, there will be heavier and heavier demands on water, only a part of which could be met by the construction of tube-wells.

Agriculture and Irrigation :

The total cultivated area in West Pakistan is at present 42 million acres, about 27 million acres in the northern region and 15 million acres in the southern region. (Fig. 7) Another 25 million acres are cultivable if water could be brought to them. At present irrigation facilities are available to only 32.8 million acres—19.5 million in the northern and 13.3 million in the southern region. Some 21.4 million acres get perennial water supply, while 11.4 million acres are irrigated during the peak flow season only. About 24 million acres are actually irrigated every year.

LAND USE IN WEST PAKISTAN

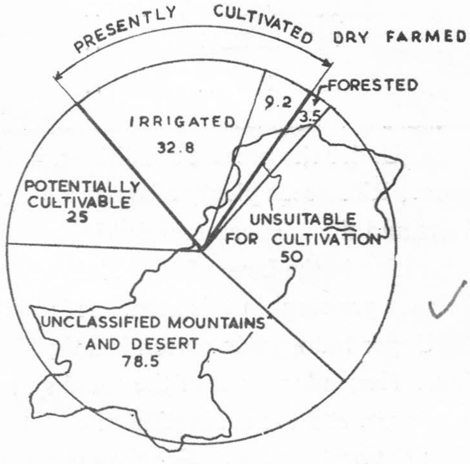


Fig. 7.

Apart from climate and soil, the amount and periodicity of irrigation water available in any culturable area mainly determine the agricultural use of the land and the cropping patterns and intensities. These in their turn have a great bearing on crop yields.

Present Cropping Patterns and Intensities[2]

The crop patterns and intensities in the present culturable commanded areas both in the Upper and Lower Indus plains are shown in the following table and are graphically represented in Figs. 8&9.

1. Supporting Studies, *op. cit.*, pp. 11-33.

2. Cropping intensities express the percentage of the culturable commanded area irrigated and cropped in either the *Rabi* or *Kharif* season.

TABLE 7

CROP PATTERNS AND INTENSITIES (1960-61)[1]

Season	Crop	Percent of Culturable Commanded Area	
		Northern region	Southern region
Kharif ..	Sugar cane	4·6	0·4
	Rice	6·0	11·4
	Cotton	11·3	6·1
	Food Grains	3·5	8·5
	Fodder and Other	15·6	3·6
	Subtotal Kharif	41·0	30·0
Rabi ..	Wheat	22·0	5·5
	Oil seeds	2·8	3·8
	Sugarcane	4·6	0·4
	Fodder and Other	11·6	17·3
	Subtotal Rabi	41·0	27·0
	Annual	82·0	57·0

Under the present conditions, in the *Kharif* season rice and cotton are the principal crops. Rice needs plenty of water and is, therefore, quite suitable for the flood plains of the rivers and the area commanded by inundation canals. It has the highest percentage under cultivation in the Lower Indus Plain where a large area is flooded, and it is the most suitable crop for growing in this area. It is the principal crop of the non-perennial areas. In the Upper Indus Plain cotton has the highest percentage of the total acreage under cultivation. Here a large net of the canal system helps the flood waters to be distributed over a large area, and the cultivation of cotton, a good cash crop and an economic user of water gives the best returns. For the same reason, sugarcane is also important in this part and occupies land throughout the year. On the other hand, in the Lower Indus Plain sugarcane is insignificant in the crop pattern on account of competition with rice.

In the *Rabi* season, the patterns and intensities of cropping are influenced by the limited supply of irrigation water available. In the Upper Indus Plain wheat occupies the most important position both in crop pattern and acreage under cultivation, as it is the chief food grain of this region and grows well under irrigation. It is estimated that of the total acreage under wheat in the Upper Indus Plain about two-thirds of the crop is grown on irrigated land. Another important reason for its high acreage is that excepting

1. Supporting Studies *op. cit.* p. 11—17 and 18.

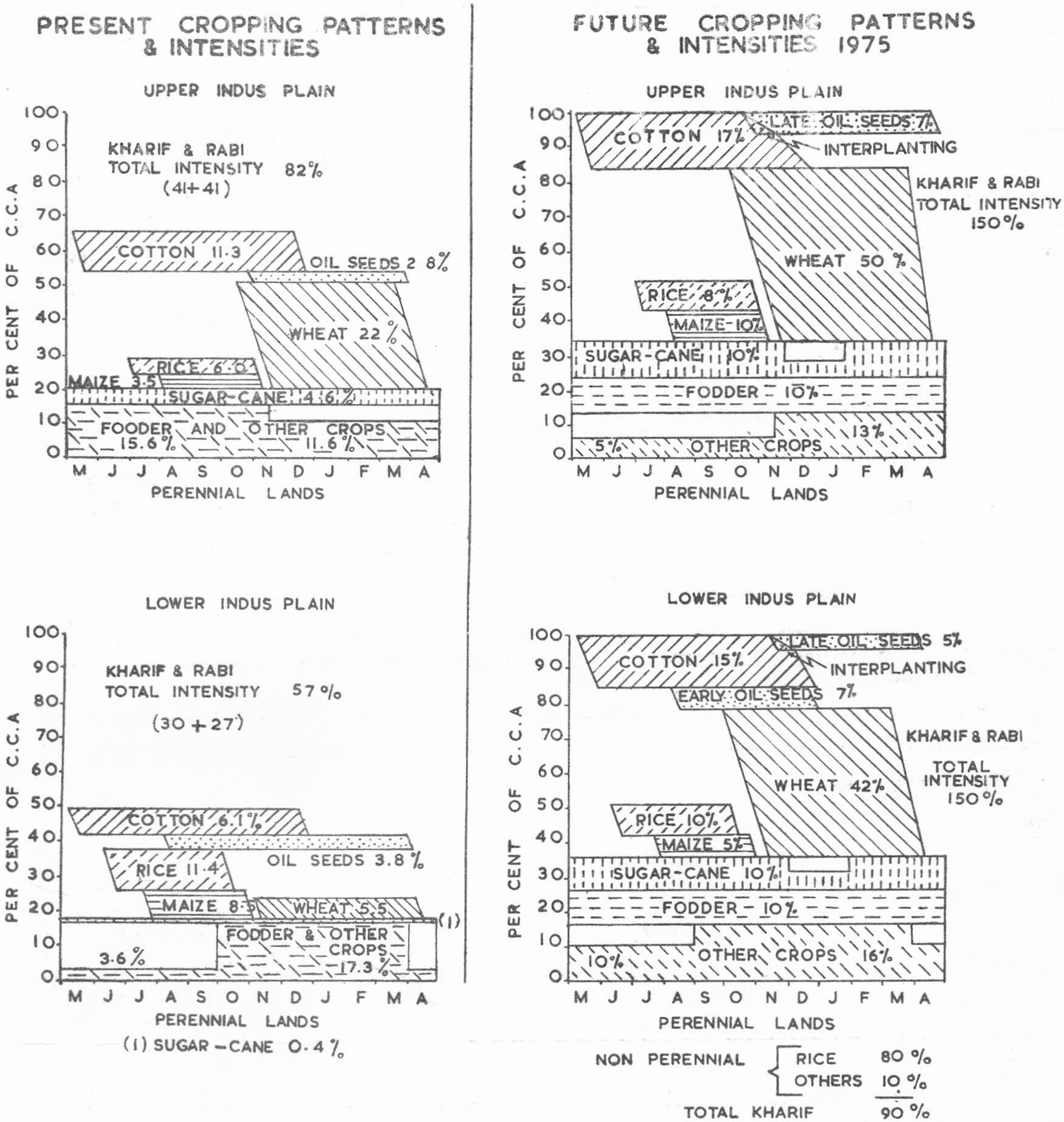


Fig. 8 and 9

1. C. C. A. Culturable Commanded Area.
2. Letters along abscissa denote months.

gram it is the most economic water user of all the winter and summer crops. In the Lower Indus Plain, wheat is less important as much less area is available under perennial irrigation.

TABLE 8

CULTIVATED AREA (000 ACRES) COMMANDED BY CANALS—1960-61[1]

Region	Area Commanded			Area irrigated		
	Perennial	Non Perennial	Total	Kharif	Rabi	Total
Upper Indus Plain	13,579	5,962	19,541	8,002	7.995	15799,
Lower Indus Plain	7'796	5,504	13,300	3,951	3,663	7,614
Total Indus Plain	21,375	11,466	32,841	11,953	11,658	23,611

Fodder is grown all the year round both in the Upper and Lower Plains to feed the cattle as there are no good natural grasslands. Patches of poor grass occur where cultivation cannot be carried on for want of water.

Future Cropping Patterns and Intensities :

During the course of the next ten years when more surface water is available for irrigation under the treaty, when more canals are constructed to carry it and their capacities are enlarged, and when ground water would be obtainable in large quantities, the crop patterns and intensities will automatically adjust themselves to this increased water supply.

The culturable commanded area is expected to be increased from the present 82 percent to 150 percent in the perennial. It is shown in the following table and graphically represented in Fig. 9.[2]

TABLE 9

CROP PATTERNS AND INTENSITIES FOR THE YEAR 1975

Session	Crop	Percent of Culturable Commanded Area	
		Northern region	Suothern region
Kharif ..	Sugar Cane	10	10
	Rice	8	10
	Cotton	17	15
	Food Grains	10	5
	Foder and Other	15	20
	Subtotal Kharif	60	60

1. Abstracted from table II—1, p. II—2 and 2 (*a*), Supporting Studies, *op. cit.*
2. Master Plan *op. cit*; p. 31.

CROP PATTERNS AND INTENSITIES FOR THE YEAR 1975—(Continued from page 22)

Season	Crop	Percent of Culturable Commanded Area	
		Northern region	Southern region
Rabi	Wheat	50	42
	Oil Seeds	7	12
	Sugarcane	10	10
	Fodder and Other	23	26
	Subtotal Rabi	90	90
	Annual Total	150	150

Cotton will still remain the most important *Kharif* crop in the Upper Indus Plain with about 50 percent increase in its intensity over that of present. With an increased regulated water supply and reclamation of saline and waterlogged areas, its intensity will considerably increase in the Lower Indus Plain from 6.1 percent to 15 percent (a rise of 50 percent), replacing rice as the most important *Kharif* crop of the perennial lands. In the Upper Indus Plain the rice acreage will also rise by 25%.

Wheat will remain the most important *Rabi* crop of the Upper Indus Plain, occupying 50% of the culturable commanded area, with a rise of 127 percent. In the Lower Indus Plain as well, cotton will become by far the most important crop, occupying 42 percent of the culturable commanded area, an increase of 66.3 percent. The increase in the intensity of cotton and wheat cultivation will be gratifying as the former is the principal earner of foreign exchange and the latter will make Pakistan self-sufficient in food grains. Another important change in the crop pattern will be that sugarcane will develop into an important cash crop in both the parts of the plain. There will be a rise of about 22 percent in its acreage in the Upper Indus Plain and as much as 25 times in the Lower Indus Plain. In the non-perennial area, rice will occupy about 80 percent out of the 90 percent of the culturable commanded area.

With the development of the irrigated lands, the production of food crops is expected to rise from the present 9.46 million tons to 19.62 million tons, almost double the present quantity.

Crop Yields and Irrigation :

A very conspicuous aspect of agriculture in West Pakistan is that the crop yields are amongst the lowest in the world, as given in the Fig. 10 and tables 10 and 11.

It will be seen that yields in West Pakistan are far below their potential. Even in comparison with Egypt, wihich is ve ry similar to West Pakistan in environment, the yields of our major irrigated crops are about one half or one-third.

COMPARATIVE CROP YIELDS PER ACRE 1961-62

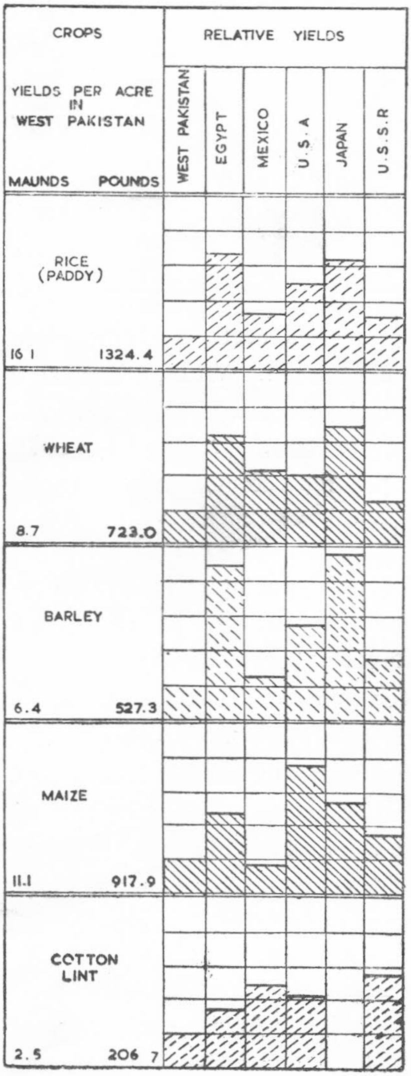


Fig. 10

Not only are the yields low, but they have not increased significantly since independence. Apart from factors such as small land holdings, cultivation practices, lack of the use of fertilizers, improved seeds and plant protection, and unsuitable crop rotation, an important cause has been inadequate and injudicious use of irrigation water. With stress on increasing the area under cultivation the water has been spread out as far as possible, resulting in thinner applications as the cultivated area increased. The thin spreading of water, apart from creating the problem of salinity, has resulted in the progressive decrease in the yield of crops. The canal irrigation system was conceived and developed as a source of revenue tothe Government, rather than as a means of maximising productivity of land irrigated. The price of water is charged on all irrigated fields carrying a crop of more than 25 percent of the normal yield. There has been no incentive for increasing the yield.

Agricultural production, thus, can be increased more economically by providing adequate supplies of surface or ground water for more intensive cropping of land already under irrigation than by the development of new land. This will also help in controlling salinity. More water is needed for flushing down the salts and more intensive cropping is required to prevent salinisation. Again, more water will be necessary with increasing use of manures. Some recent studies have shown that it is desirable to increase the delta for various crops by at least 25 percent.[1] All this implies that a substantial portion of our future development of surface water resources will be absorbed in lands presently under irrigation, and we will have to look more to ground water for the development of new lands.

1. Majid and Asghar, Some aspects of irrigation practices in Punjab, Research Publication Vol. II, No. 3., Government Printing, Lahore, 1956.

TABLE 10

YIELDS PER ACRE (1961-62) [1]

Country		Rice (paddy)	Wheat	Barley	Maize	Cotton
West Pakistan	lbs. ..	1324·4	723·0	527·3	917·9	206·7
	Mds. ..	16·1	8·7	6·4	11·1	2·5
Egypt	lbs. ..	4505·4	2197·7	2328·5	2141·1	356·8
	Mds. ..	58·4	26·6	28·4	26·0	4·3
Mexico	lbs. ..	2285·5	1498·8	686·1	776·1	490·6
	Mds. ..	27·8	18·2	8·3	9·4	5·9
Japan	lbs. ..	4193·1	2444·4	2551·1	2480·8	..
	Mds. ..	51·0	29·7	31·0	29·3	..
U.S.S.R.	lbs. ..	2141·1	945·6	832·2	1650·5	579·9
	Mds. ..	26·0	11·5	10·7	20·5	7·0

With the provision of adequate water and the employment of improved farm practices, increases in average yields are anticipated for all crops amounting to about 100 percent for the irrigated areas of the Upper Indus Plain and about 73 and 53 percent respectively for the perennial and non-perennial areas of the Lower Indus Plain, as shown in the table 11 below.[2]

TABLE 11

ANTICIPATED AVERAGE CROP YIELDS FROM IRRIGATED LANDS

MAUNDS AND POUNDS PER HARVESTED ACRE

Crop	1949—1959 Average		Future Yields—1975			
	Maunds	Pounds	Northern region Maunds	Pounds	Southern region Maunds	Pounds
Rice (cleaned) . ..	9·2	760	17·2	1420	15·3	1245
Wheat	8·7	720	18·7	1500	12·0	990
Barley	7.3	600	15·3	1260	8·5	700
Maize	10·9	895	21·0	1730	9·0	740
Cotton Lint	2·2	185	3·9	320	4·2	345
Cane-sugar	31·3	2580	61·0	5020	69·5	5720

1. Yearbook F.A.O. 1930. Figures for West Pakistan from Statistical Handbook of West Pakistan Figures for paddy have been calcuated from cleared rice in the ratio of 8 to 5.

2. Master Plan of *op. cit.* p. 29.

Reclamation of Lands :

A large quantitiy of water will be required for the reclamation of our saline lands. A comprehensive survey of the Indus Plain completed in 1958,[1] showed that about 11.3 million acres of irrigated land in the Indus Plain were waterlogged or poorly drained, another 4.8 million acres were severely saline and in an additional 11.2 million acres saline patches were common. Since that survey, another half a million acres are estimated to have been seriously affected. It is estimated that West Pakistan is losing 100,000 acres each year through the spread of waterlogging and salinity. Reclamation of these lands is necessary for increasing argicultural production. This will require extensive use of tubewells as the flatness of the country prevents drainage over large areas.

The basic principle in the reclamation of saline lands is to wash down the salts by supplying copious watering. For this more irrigation water is required. To reclaim 40,000 acres, which are affected by salt every year in the Punjab region alone, about 7500 cusecs are needed while only 4000 cusecs are available. Thus, at present more land is being lost through salinity than is being reclaimed.

The reclamation programme now under execution by Water and Power Development Authority includes 26 projects, which will benefit 29 million acres under the command of the existing systems (Fig. 11). The ten reclamation projects of the Upper Indus Plain are based primarily on the utilization of tubewells for sub-soil drainage, combined with drainage for the removal of stormy run-off. In the Lower Indus Plain, reclamation project consists primarily of open drains for the removal of sub-soil and surface water, supplemented with tubewells in those areas where it is feasible to provide sub-soil drainage by this means.

The program envisages construction of works for about 11.5 million acres in the Upper Indus Plain and 6 million acres in the Lower Indus Plain. On the average, over 2500 tubewells will be constructed annually, besides other works. The anticipated rate of reclamation will average about 1.0 million acres per year in the Upper Indus Plain and 0.5 acres per year in the Lower Indus Plain.

At Jaranwala, about 45 miles from Lahore, within three years of pumping by deep tubewells saline patches have been reduced by 50 percent and the food production has increased by 80 percent.

In view of the high salinity of the ground water in the Lower Indus Plain, it shall have to mainly depend upon the surface water which can be carried by the Indus. It has to be kept free from salt to prevent further deterioration in agricultural productivity. That will be necessary even to develop ground water in riverain lands. Any programme of the reclamation of the Upper Indus Plain to reduce salinity would thus require the disposal of saline water by drainage independent of the Indus so that its waters are not contaminated.

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1. Land Forms, Soil and Land-use of the Indus Plains, West Pakistan Colombo Plan Cooperation Project, 1958.

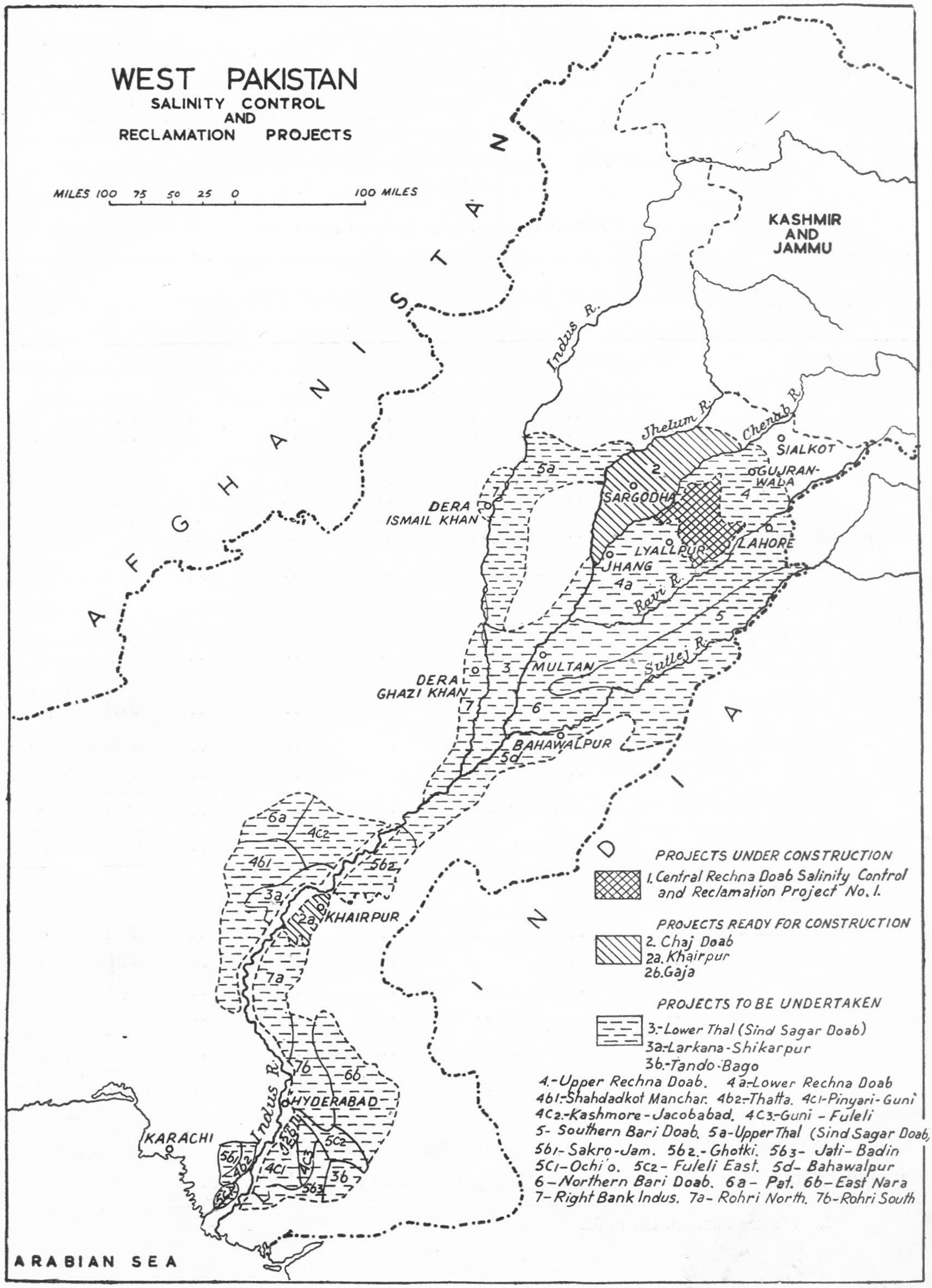
WEST PAKISTAN
SALINITY CONTROL
AND
RECLAMATION PROJECTS
MILES 100 75 50 25 0 100 MILES
AFGHANISTAN
KASHMIR AND JAMMU
INDIA
Indus R.
Jhelum R.
Chenab R.
Ravi R.
Sutlej R.
SIALKOT
GUJRANWALA
SARGODHA
LYALLPUR
LAHORE
JHANG
DERA ISMAIL KHAN
MULTAN
DERA GHAZI KHAN
BAHAWALPUR
KHAIRPUR
HYDERABAD
KARACHI
ARABIAN SEA
PROJECTS UNDER CONSTRUCTION
1. Central Rechna Doab Salinity Control and Reclamation Project No. 1.
PROJECTS READY FOR CONSTRUCTION
2. Chaj Doab
2a. Khairpur
2b. Gaja
PROJECTS TO BE UNDERTAKEN
3.- Lower Thal (Sind Sagar Doab)
3a.- Larkana - Shikarpur
3b.- Tando - Bago
4.- Upper Rechna Doab. 4a.- Lower Rechna Doab
4b1.- Shahdadkot Manchar. 4b2.- Thatta. 4c1- Pinyari - Guni
4c2.- Kashmore - Jacobabad. 4c3.- Guni - Fuleli
5- Southern Bari Doab. 5a- Upper Thal (Sind Sagar Doab)
5b1- Sakro - Jam. 5b2.- Ghotki. 5b3- Jati - Badin
5c1- Ochi'o. 5c2- Fuleli East. 5d- Bahawalpur
6- Northern Bari Doab. 6a- Pat. 6b- East Nara
7- Right Bank Indus. 7a- Rohri North. 7b- Rohri South

Fig. 11

Food and Population :

The primary aim of the expansion of irrigation facilities and reclamation projects is to increase production not only for the present population but also for the increasing numbers. The net availability of food in 1961 and the potential for 1975 is given in the following table.

TABLE 12[1]

NET AVAILABLE FOOD (MILLION TONS)

Product	1961 Supply	1975 Potential
Food Grains		
Rice }	6·14	2·95
Wheat }	..	5·63
Barley }	..	0·11
Sorghum }	0·46	0·27
Millet }	..	0·28
Maize }	..	0·45
Subtotal	6·60	9·69
Other		
Gram }		0·27
Other Pulses }	0·33	0·13
Oil Seeds }		0·17
Cane sugar	0·69	4·09
Vegetables and miscellaneous	0·96	3·36
Fruits	0·88	1·91
Subtotal	2·86	9·93
Total Crops	9·46	19·62
Animal Products		
Meat and Fish	0·31	0·45
Eggs	0·01	0·03
Milk	2·05	4·82
Oils and fats	0·15	0·30
Subtotal	2·52	5.60
Grand total	11·98	25·22

The present supply of food for a population of 42.9 million is about 12 million tons, including imports of 1 million tons. If the programme of development is executed accord-

1. Master Plan *op. cit.* p. 32.

ing to the plan, an additional water supply will be available which combined with land reclamation will increase agricultural production to 25 million tons—more than twice the present production. It will provide for the anticipated population of 65 million in 1975 with a diet containing the equivalent of 2300 calories per capita per day, the minimum level recommended by the United Nations plus a proportionate increase in industrial raw materials and exports.[1] The present gross value of crops, about Rs. 4000 million, will be increased toRs. 9,100 million.

Conclusion

From what has been said above, it becomes abundantly clear that the future of West Pakistan, with its wide distribution of arid lands, lies in the harnessing of its rivers and ground water reservoir and the equitable distribution and judicious use of water. If the water available in the Indus and its tributaries is properly tapped and regulated in terms of the Indus Waters Treaty and other water resources underneath the Indus plain and of the areas bordering it are adequately developed, it should substantally meet our present requirements as well as those of the foreseeable future.

But the whole of the Indus basin is to be developed as a unit, keeping in view the balanced growth of both the northern and southern regions. In such a scheme, the Indus will have to play a double role (1) to replace water in the Upper Indus Plain taken away by by India and (2) to maintain a steady flow in winter for the Lower Indus Plain. The latter relies almost entirely on the Indus component during the winter months since the Punjab rivers are drained practically dry by the time they reach the confluence.

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1. Master Plan *op. cit.* p. 32.

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CLIMATOLOGY OF ISLAMABAD THE CAPITAL OF PAKISTAN

BY

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Introduction :

The site selected for the new Capital of Pakistan lies on a plateau bordered in the north and east by the hill ranges of Siwalik formation at an elevation of 1,500 ft. to 5,000 ft. and ultimately merges into the Galies and the Murree hills. It is drained by the Rawal and the Soan rivers and their numerous perennial and seasonal tributaries. The sudden rise of the land from about 1,500 ft. to 5,000 ft. in the Federal Capital Area itself gives rise to rapid variation in the various climatic elements due to the variations of height and topography. The biotic potential of the land is fairly high, but it has been subject to erosion and is badly cut at places by various drainage channels. The climatological features of this area are discussed below.

Temperature :

The temperature conditions of Rawalpindi (illustrated in Fig. 1) are fairly representative of the plain strip of land at the foot of hills in the Potwar Plateau. This area is cold in winter and hot in summer. The coldest month is January when the mean daily maximum temperature is 62.3°F., and the mean daily minimum is 37.9°F, the mean being 50.1°F. In this month the mean of the lowest minimum temperatures recorded in different years since 1881 is 30.8°F and the lowest minimum temperature was 25°F recorded on the 14th January 1937.

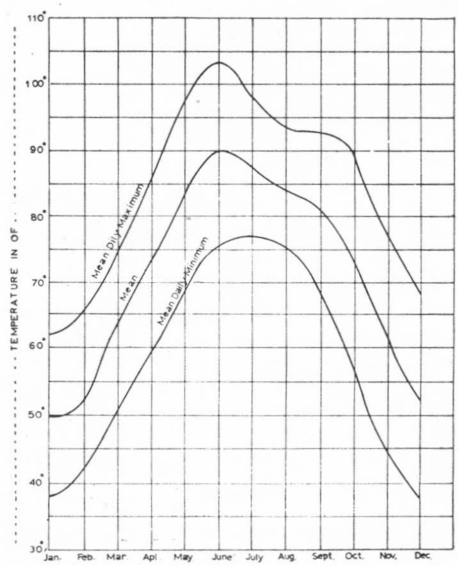

Fig. 1. ANNUAL MARCH OF TEMPERATURE AT RAWALPINDI

From February to May the mean daily maximum and minimum temperatures rise at the rate of about 10°F during successive months. The highest value is reached in June when the hot season is at its climax. In this month the mean daily maximum and minimum temperatures are 103.5°F and 75.9°F respectively. The mean of the highest maximum temperatures of different years is 113°F with the highest temperature of 117°F recorded in 1929.

Although the highest temperature recorded in July is the same as in June *viz.*, 117°F, the mean daily maximum temperature falls to 98°F on the onset of monsoon. It further falls to 94°F in August and to 93°F in September, but the minimum temperatures do not show any marked fall during July and August.

Rapid coolling of air in the region starts in October when the mean minimum temperature falls by about 12°F, while maximum temperature falls by about 5°F only. In November, with its clear nights, the fall in day and night temperature is very considerable. The mean daily maximum temperature falls by 11° to 78°F., while the mean daily minimum temperature falls by 13° to 44°F. In fact November is almost a cold month, and climatologically speaking the change from October to November is sudden and considerable. The nights in December are practically as cool as in January. The day temperatures are however, higher by about 5°F as compared to January.

As we proceed northward up the mountains, the temperatures in winter and summer fall considerably with height but the day temperature falls more rapidly than the night temperature, the rate of fall being nearly double during day time. This becomes evident by a fall being nearly double during day time. This becomes evident by a study of temperatures at Murree where the daily minimum temperature in January goes down to about 31°F, while the mean daily maximum tempearture even in June, the hottest month, does not rise above 81°F. The annual march of temperature over Murree, as given in Fig. 2, follows the general pattern of Rawalpindi, except for the fact that the mean daily range of temperature is less over Murree than at Rawalpindi.

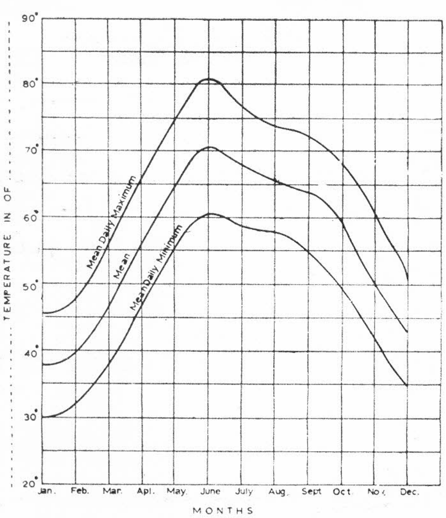

Fig. 2. ANNUAL MARCH OF TEMPERATURE AT MURREE

Faruqi, 3.x.64

The meteorological observatory at Rawalpindi is about 1674 feet *a.s.l.*, while the observatory at Murree is 7100 ft. *a.s.l.* For a difference of height of over 5000 ft. the temperature should normally differ by about 16°F and this agrees fairly well with the difference between annual mean temperature of the two places, as it is 17.4°F. But the difference in the day and night temperatures at the two stations varies considerably from the above value, being 22.8°F for the maximum temperatures in June and 2.9°F for the minimum value in December.

In order to study the effect of elevation and topography on the fall of temperature, the values of the rate of fall of the mean daily maximum and minimum temperatures per 1000 ft. for Khushab and Rawalpindi and Rawalpindi and Murree are plotted on graphs I to IV in Figure 3. From the Graphs, it is clear that the mean maximum and minimum temperatures fall by about 6°F between Khushab and Rawalpindi per 1000 ft. This rate of fall is almost double the value computed on the basis of normal lapse rate of temperature in free air.

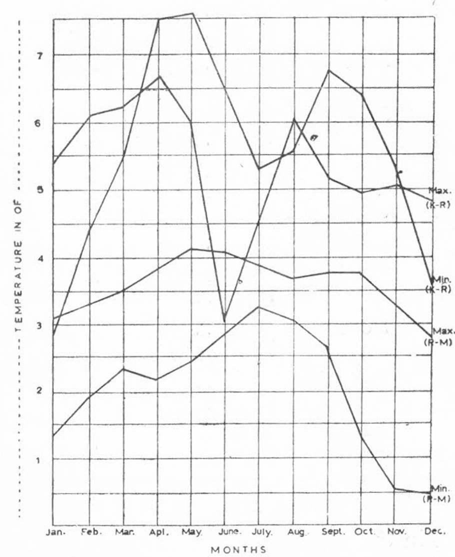

Fig. 3. RATE OF FALL OF TEMPERATURE PER 1000 Ft. BETWEEN KHUSHAB-RAWALPINDI AND RAWALPINDI-MURREE

Faruqi

On the other hand, the rate of fall in day temperature between Rawalpindi and Murree is about 3°F to 4°F per 1000 ft. and for night temperature it is generally 2-3°F in summer and is as small as 1°F per 1000 ft. in the winter months. The marked differences noted in the temperature variation per 1000 ft. over the Potwar Plateau as compared to the Punjab plains bring out the characteristic features of the two regions. It is clear that while superadiabatic lapse rates characterise the Punjab plains the Powtar plateau is greatly influenced by anabatic effect in dry air during day time and by katabatic flowduring night. These effects are particularly marked in the summer and winter months. Thus at higher elevations over the Federal Capital Area there will be considerable relief from high temperatures in summer during day time, but the minimum temperatures are not likely to be much lower than those at Rawalpindi, particularly in the winter months.

Humidity :

The hygrometric normals for Rawalpindi and Murree are given in Table 1 for a comparative study.

TABLE 1

MONTHLY MEAN RELATIVE HUMIDITY AT 0300 AND 1200 GMT.

Months		Rawalpindi	Murree
January	I	83	62
	II	46	59
February	I	81	64
	II	50	68
March	I	63	55
	II	39	59

MONTHLY MEAN RELATIVE HUMIDITY AT 0300 AND 1200 GMT.—(Continued from page 33)

Months		Rawalpindi	Murree
April	I	51	50
	II	29	47
May	I	35	42
	II	17	32
June	I	38	53
	II	29	55
July	I	67	78
	II	48	75
August	I	75	88
	II	52	79
September	I	62	69
	II	37	61
October	I	58	49
	II	29	46
November	I	67	43
	II	29	42
December	I	77	50
	II	41	49
Annual	I	63	57
Mean	II	37	56

The mean annual humidity at Rawalpindi is 63 per cent. in the morning and 37 per cent. in the afternoon, the mean being 50 per cent. while at Murree it is about 75 per cent throughout the day. There is thus no marked diurnal variation of humidity at Murree, and on the average it rises by about 3 per cent for every 2000 ft. as we move to higher elevations in the Federal Capital Area. In different months, however, the humidity conditions and the associated comfort levels show considerable fluctuations at Rawalpindi in the morning and afternoon and from season to season.

Mornings at Rawalpindi during the winter months of December, January and February, with minimum temperature below 40°F and humidity about 80 per cent or more, are unpleasantly cold, particularly when a northerly wind is blowing. In the afternoon the humidity even in these months is between 40 per cent and 50 per cent, and temperatures range between 60°F. and 7°F. thus making the weather quite pleasant.

In March and April the humidity is generally between 30 per cent. and 65 per cent and with the usual mild temperatures it continues to be within the pleasant range. May and June are the driest months. Even in the morning the mean humidity is about 35 percent. to 40 per cent. while in the afternoon, with temperatures above 90°F, the humidity is occasionally very low indeed, the mean for the month of May being over 17 per cent. This is the period of most irritating weather.

July and August are the most moist months at Rawalpindi and the humidity even in the afternoon is generally not below 50 per cent, while in the mornings the values fluctuate between 60 per cent and 80 per cent. The wet bulb temperature in this period is always above 75°F, and it must be depressing or uncomfortable for most of the time.

The post-monsoon period (mid-September to November) is like the spring, with high humidity in the morning and low values of the order of 30 per cent. in the afternoon. With temperatures below 90°F. it should not be unpleasant.

At Murree the difference in the morning and afternoon humidities is generally less than 4 per cent. except in May, August and September when it is 8 per cent. The actual values are also not far beyond the comfortable range and vary between 40 per cent. and 70 percent. except during the monsoon period when the humidity varies between 75 per cent. and 90 percent.

This characteristic variation in the humidity and comfort conditions between Rawalpindi and Murree is fully explained if one looks up the differences in the normals of dry bulb and wet bulb temperature and vapour pressures of the two places for the morning and the afternoon, which are given in Table II.

TABLE 2

MEAN DRY BULB, WET BULB AND VAPOUR PRESURE AT RAWALPINDI AND MURREE AND THEIR DIFFERENCE, AT 0300 AND 1200 GMT

Month		Mean Dry Bulb			Mean Wet Bulb			Vapour Pressure (mb)		
		Rawalpindi	Murree	Difference	Rawalpindi	Murree	Difference	Rawalpindi	Murree	Difference
January	I ..	40.7	36.5	4.2	38.8	31.9	6.9	7.2	4.4	2.8
	II ..	58.0	39.0	19.0	48.2	33.9	14.3	7.4	4.6	2.8
February	I ..	45.2	37.2	88.0	42.9	32.8	10.0	8.3	4.7	3.6
	II ..	61.7	41.2	20.5	51.8	36.6	15.2	9.0	5.7	3.3
March	I ..	55.5	44.7	10.8	49.6	38.2	11.4	10.5	5.4	5.1
	II ..	69.9	47.1	22.8	55.9	40.5	15.4	9.2	6.2	3.0
April	I ..	67.7	54.3	13.4	57.8	45.6	12.2	12.9	7.2	5.9
	II ..	82.5	58.3	24.2	62.3	47.7	14.6	10.4	7.4	3.4
May	I ..	80.5	64.2	16.3	63.6	51.7	11.9	14.2	8.5	5.7
	II ..	100.0	74.0	26.0	69.1	55.9	13.2	11.1	8.8	2.3
June	I ..	86.5	68.7	17.8	69.2	58.0	11.2	18.1	12.3	6.0
	II ..	99.4	74.1	25.3	74.1	61.4	12.7	18.1	13.9	4.2
July	I ..	83.6	66.1	17.5	75.4	61.6	13.8	26.5	17.2	9.3
	II ..	95.4	71.9	23.2	78.0	65.8	12.2	26.6	19.4	7.2
August	I ..	80.6	63.5	17.1	74.8	61.2	13.6	27.7	17.7	10.0
	II ..	92.6	69.7	22.9	77.4	65.1	12.3	25.3	19.4	5.9
September	I ..	75.8	60.6	15.2	67.2	54.6	12.6	21.7	12.8	8.9
	II .	82.7	68.4	14.3	72.7	59.5	13.2	18.8	14.0	4.8
October	I .	63.5	54.7	8.8	55.7	45.5	10.2	12.4	6.9	5.5
	II .	84.9	60.8	24.1	64.1	49.6	14.5	11.5	8.1	3.4
November	I .	48.4	47.1	1.3	43·9	38.3	5.6	8.0	4.3	3.7
	II .	72.1	50.9	12.2	55·5	33.8	4.1	6.7	3.9	2.9
	II .	60.9	42.3	18.6	49·5	35.5	14.3	7.2	4.3	4.9
Annual Mean	I .	64.0	53.2	10.8	56.4	46.1	10.3	14.5	8.7	5.8
	II .	80.8	15.1	32.7	63.3	49.3	14.0	13.5	9.8	3.7

It is also noticed that while the mean annual vapour pressure at Rawalpindi is 14 mb it is only 9.2 mb at Murree. This decrease in the vapour content of the air at Murree is certainly due to different hygrometric table. The rate of fall of wet bulb temperature between Rawalpindi and Murree is more or less uniform throughout the year with little difference between day and night except in the winter months. The rate of fall of wet bulb temperature with height in the region is about 2.5°F/1000 ft. At Rawalpindi the wet bulb temperature enters the range of discomfort and low capacity of work in June, July and August when its value ranges from 70-75°F. The parts of the Federal Capital Area sited at a height of 1000 to 2000 ft. higher than Rawalpindi will remain outside the uncomfortable limits of humidity and wet bulb temperature practically throughout the year.

Wind direction is an element which is very sensitive to the conditions of exposure of the recording instrument. The wind frequencies for Rawalpindi given in Table III refer to the wind vane which was situated at the Central Telegraph Office on the Mall, while the frequencies of wind for Murree refer to the top of the church at nearly the highest point in the neighbourhood of the Mall. This explains for the more regular variation of wind directions in different seasons at the latter.

TABLE III

RAWALPINDI

PERCENTAGE NO. OF DAYS OF WIND FROM

		N	NE	E	SE	S	SW	W	NW	Calm.
January	I ..	6	5	2	2	2	4	7	5	67
	II ..	0	8	0	3	1	38	21	14	15
February	I ..	8	8	5	2	2	5	9	6	62
	II ..	1	14	1	1	3	39	17	11	13
March	I ..	10	9	3	3	2	4	11	9	49
	II ..	1	12	0	5	0	33	15	21	10
April	I ..	8	10	4	3	3	7	12	7	46
	II ..	1	15	0	3	1	27	17	28	8
May	I ..	7	8	5	5	3	3	8	9	52
	II ..	4	6	1	7	3	23	14	28	14
June	I ..	7	12	9	13	6	1	3	4	44
	II ..	2	11	2	17	3	35	5	12	13
July	I ..	6	13	11	15	8	2	2	2	41
	II ..	0	10	0	42	6	20	3	2	17
August	I ..	6	9	9	12	5	2	1	2	55
	II ..	1	10	1	29	6	21	3	5	24
September	I ..	10	8	6	4	3	3	3	4	59
	II ..	2	7	0	11	1	28	5	21	25
Octover	I ..	5	6	2	2	1	2	5	6	70
	II ..	2	5	1	3	0	27	14	18	30
November	II ..	6	3	3	1	1	2	4	5	75
	II ..	1	0	0	1	1	31	21	20	25
December	I ..	3	3	1	1	1	4	8	4	75
	II ..	1	6	1	3	0	31	22	15	21
Annual Mean	I ..	7	8	5	5	3	3	6	5	58
	II ..	1	9	1	10	2	29	13	17	18

MURREE

PERCENTAGE NO. OF DAYS OF WIND FROM

		N	NE	E	SE	S	SW	W	NW	Clam
January	I ..	5	3	9	31	16	2	0	1	33
	II ..	3	6	24	36	6	2	5	5	12
February	I ..	7	2	9	32	11	1	0	2	35
	II ..	0	3	17	35	10	5	11	6	14
March	I ..	11	4	5	28	12	1	0	5	34
	II ..	2	6	12	35	10	9	13	8	3
April	I ..	12	3	8	21	10	1	1	4	41
	II ..	1	7	9	25	9	13	20	9	6
May	I ..	17	3	5	13	8	2	0	6	46
	II ..		5	7	8	7	17	37	17	2
June	I ..	7	2	5	18	9	2	1	33	5
	II ..	5	6	4	13	12	17	30	13	0
July	I ..	8	3	13	15	8	2	1	6	55
	II ..	3	1	5	17	10	19	32	10	2
August	I ..	10	1	2	15	5	1	1	6	59
	II ..	1	1	3	15	12	15	32	14	6
September	I ..	15	5	3	10	3	1	1	8	54
	II ..	1	3	3	9	7	14	43	17	2
October	I ..	22	5	3	8	6	2	1	8	46
	II ..	2	3	6	17	11	14	34	12	1
November	I ..	15	3	4	11	7	1	1	5	54
	II ..	1	5	3	17	5	11	29	17	11
December	I ..	9	6	5	22	9	2	1	1	45
	II ..	7	12	13	30	5	3	11	14	5
Annual	I	11	3	5	19	9	1	1	5	46
Mean	II	2	5	9	21	9	11	26	12	5

At Rawalpindi the wind in the morning is calm on 58 per cent. occasions, while it is calm on hardly 18 per cent. occasions in the afternoon. When the wind is blowing in the morning, it generally veers from W to NE in the winter season and from NE to SE in summer. In the afternoon the most predominant direction throughout the year is SW, while the other prevalent directions are W to NW in winter and NE to SE in summer. In spite of the fact that there is a complete reversal of winds from winter to summer due to the monsoons, the South-westerly continues to be the predominant wind throughout the year in the afternoon.

At Murree the wind in the morning is calm on 46 per cent. occasions, while it is calm only on 5 per cent. occasions in the afternoon. In winter when the wind blows it is usually from East to South-east with a good percentage of southerly component. This is in accordance with the general meteorological features of the area. The western disturbances which influence the weather over West Pakistan, are in fact occluded and extra-tropical in nature. They are more pronounced at higher elevations and affect the surface wind of Murree more than the surface wind at Rawalpindi.

During summer and Monsoon period Southeasterly to Southerly winds are more predominant in the morning. Southwest to Westerly winds prevail in the evening. On the whole as we go higher up from Rawalpindi the winds will veer with elevation. The most predominant wind in the evening will be from southwest.

Wind speed at Rawalpindi is usually low, the mean annual wind speed being 1.9 m.p.h. It is lowest in November when it is 1.3 m.p.h. and highest in April when it reaches the value of 2.7 m.p.h. In individual weather conditions, however, winds with much higher speed are met with and may occasionally reach 70 to 80 m.p.h. in a squall or a thunderstorm. On the other hand at Murree the mean wind speed is 5 to 6 m.p.h. from December to April and varies from 3.7 m.p.h. to 5.2. m.p.h. during the remaining months of the year. The annual mean wind speed is 4.9 m.p.h. The mean wind speed thus increases over the Potwar Plateau with higher elevation at the rate of 1.m.p.h. per 2000 ft.

Cloud :

The total cloud amount at Rawalpindi varies from 3-4/10 from December to April. In May and June it is about 2/10, but increases to 4/10 in July and August. It is only 1-2/10 during the period from September to November. The cloud amount at Murree follows the pattern of Rawalpindi except that it is about 5 per cent. more clouded at Murree in each month.

Rainfall :

The normals of monthly total rainfall at Rawalpindi and Murree are given in Table IV.

TABLE IV

MEAN MONTHLY RAINFALL AT RAWALPINDI AND MURREE (Inches)

Months	Rawalpindi	Murree
January	2.49	3.79
February	2.48	4.31
March	2.67	4.81
April	1.92	4.13
May	1.25	2.62
June	2.31	3.98
July	8.07	12.40
August	9.17	13.81
September	3.89	5.42
October	0.60	1.56
November	0.28	0.73
December	1.24	1.80
Annual Total	36.37	59.36

It may be noticed that the area has two distinct rainfall seasons—the late summer season from July to September and the winter-spring season from December to April. The bulk of the monsoon precipitation in Rawalpindi occurs in July and August with monthly average of 8″ and 9″ respectively. The monsoon precipitation is associated with the convergence of the Arabian Sea and Bay of Bengal currents in the upper air when a tropical depression is situated over central parts of India or when it is actually centred in the neighbourhood of the region itself.

In September when this convergence zone shifts southwards there is a marked decrease in rainfall of the area. Rainfall decreases further after the withdrawal of the monsoon, and November is uually the driest month of the year. With the onset of winter in December, rainfall activity is revived and the area gets appreciable winter rainfall, which is characteristic of the Mediterranean type of climate. The months of January, February and March each receive on an average about 2½″ of rainfall, which is generally sufficient for dry farming if uniformaly distributed. The actual rainfall in any month, however, may very considerably from the mean in different years. During winter the highest total rainfall of a month was 8.4″, which occurred in January 1911. During August the highest rainfall record pertains to 1916 when a total of 23.6″ of rain was received in the month.

The winter rainfall is associated with the passage of western disturbances which move eastwards from Iran and Afghanistan. An active western disturbance can induce fairly heavy rain. In some of the heaviest falls in winter, amounts as high as 3″ to 4″ have been reported in 24 hours. But the intensity of heavy rainfall is far greater in the monsoon season than in winter. The heaviest fall of 9.8″ in 24 hours was reported on 28 August, 1929. The amounts of these heavy falls, though rare, are particularly important for planning of the drainage system of the area. For this purpose it may be noted that the highest intensity in short durations up to an hour or so may reach a value as high as 4.″ to 5″ per hour.

The mean annual rainfall for Murree is 59″ as compared to 36″ of rainfall at Rawalpindi. The mean monthly rainfall at Murree during July, August and September is 12.4″, 13.8″ and 5.4″ respectively. The winter rainfall at Murree is also considerably higher than at Rawalpindi and is usually of the order of 4″ in each month from January to April.

Though there are two well marked rainy seasons at Rawalpindi, some rainfall is received in all the months, but the number of days with rainfall of 0.1″ or more varies from 2 in December to 4.7 in June. In July and August the number of such rainy days is 8.8 and 9.1 respectively. It falls to 4.6 in September and then 1.4 in October. November has as an average only 1 rainy day in two years.

The number of rainy days in Murree is larger than Rawalpindi. It is about 6 to 7 days in each of the months from January to April. Then the number decreases to 5 and 6 in May and June. There is a sudden increase in July and August with the average of 13-14 rainy days. In September the number of rainy days is 7 and in October 3 only. As in Rawalpindi, November is the driest month with only 12 rainy days in 10 years.

Over the Capital Area the number of rainy days will vary in a similar way. October and November will be the driest months. During the monsoon months from July to September, the number of rainy days will be 10 to 12. Winter months from December to March will have about 3 to 4 rainy days per month.

Thus, from the climatological point of view, the rainfall pattern at Islamabad resembles the middle latitudes climates during winter and the monsoon climates in summer.

Thunderstorms :

Thunderstorm activity is most pronounced during July and August when 13-14 thunderstorms are recorded in winter months. In March, 3 thunderstorms are reported but the number increase to 6 in April and to 8 in June. In September and October, 7 and 3 thunderstorms are reported respectively. Hailstorms are rare in Rawalpindi area, and on an average only one hailscorm is likely to occur in March. But the chances of hailstorms during the monsoon period are only 1 to 2 in a decade.

At Murree the thunderstorm activity is most pronounced in the monsoon season and less in winter. The number of thunderstorms reported in June, July and August are 10, 13 and 11 respectively. During the premonsoon and the post-monsoon months, the number of thunderstorms recorded in each month varies from 5 to 9. The highest frequency of hailstorms is reported from February to April when 2-4 hailstorms occur in each month. During July and August the chances of a hailstorms are only once in two years.

Fog :

The surface visibility in the morning is generally good in Rawalpindi throughout the year. There are, however, about 8 days in a year when the visibility deteriorates to 1100 yards and 60 days when it is between 1100 yards to 2.5 miles. During the rest of the year it is always greater than 2.5 miles. The days of poor visibility occur mostly in winter months from December to March. The visibility improves considerably in the afternoon.

At Murree, on the other hand, the days of poor visibility in the morning and evening are evenly distributed. The number of days in a year when visibility is less than 1100 yards is 27 in the morning and 29 in the evening. The number of days when surface visibility is between 1100 yards and 2.5 miles are 16 in the moring and 22 in the evening.

At higher elevations in the Capital Area the days of poor visibility (upto 1100 yards) are expected to be between 15 to 20 and will be more evenly distributed in the morning and evening than at Rawalpindi.

Conclusion :

The climate of Islamabad in Potwar Plateau is found to be quite distinct from that of the Punjab plains and is greatly influenced by anabatic effect in dry air during day time and by katabatic flow during nights. These effects are particularly will marked in the summer and the winter months. The climatic conditions of the new Federal Capital generally follow the pattern of Rawalpindi, but the day temperatures decrease by about 3°F to 4°F for every 1000 ft. in height, while the fall in night tempertatures with height is much less and may be as small as 1°F/1000 ft. in winter months and 2°F to 3°F in summer.

The mean annual humidity is generally about 60 per cent. in the morning and about 40 per cent. in the afternoon, with large seasonal variation. The differences in the value of the morning and the afternoon humidity is, however, less as we go higher up. At Rawalpindi the wet bulb temperature enters the range of discomfort and low capacity of work in June, July and August when the values are generally above 75°F. Thus, the weather in the summer months is very dry and irritating. The areas of Islamabad located 1000 ft. to 2000 ft. higher than Rawalpindi are, thus, outside the uncomfortable limits of humidity and wet bulb temperature throughout the year.

Islamabad has two distinct rainfall seasons, the summer season from July to September and the winter-spring season from December to April. The bulk of the monsoon precipitation occurs in July and August due to the convergence of the Arabian Sea and Bay of Bengal currents in upper air in association with tropical depressions lying over central parts of India or moving towards the area itself.

The winter rainfall over the region is associated with western disturbances which move eastwards from Iran and Afghanistan. Thus the rainfall pattern at Islamabad reflects a combination of sub-tropical conditions with a distinct moonsoonal touch.

The variation of wind with height is found to be considerable and is greatly influenced by topography.

SUGAR FACTORY INDUSTRY OF WEST PAKISTAN

BY

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Sugar, an important constituent of the daily diet is obtained from various sources. In West Pakistan 96.7% of the total white sugar produced in 1961-62 was derived from sugarcane. A very large section of the population lives in rural areas (81.5%[1] in West and 94.9% in East Pakistan) and the per capita annual income[2] is only Rs. 261. With such a meagre income the consumption of white sugar per capita is very small, only about 7 lbs[3] (1961-62). Much of the sugar requirements of the rural masses are fulfilled by *Gur* and *Desi* sugar or *Khandsari.* West Pakistan, which has a higher ratio of urban population (22.5%) and a better standard of living than East Pakistan, has a greater consumption of white sugar; and with greater urbanization the demand should increase.

The sugar factory industry has accordingly been given great attention in all the development plans as one of the major food industries of the country.

The development of the sugar factory industry can be traced in four phases from the time of independence to date.

The Industry at the time of Independence

At the time of independence in 1947 the Sugar industry was in a very poor condition. There were only eight sugar mills, of which only two were in West Pakistan—one at Rahwali (Gujranwala) established in 1936 the other at Takhti-Bahi near Mardan established in 1938-39. The reasons for this poor heritage were many. Most of the sugar mills in pre-partition India were located in the central part of the northern sugarcane belt in what was then the provinces of Bihar and U.P. India had been a very large producer of sugarcane, most of which was converted into *Gur* and *Desi* sugar, and almost all the white sugar was imported from the tropical countries. The first sugar mill was established in 1902 in Bihar. Later on many more mills were established in the main sugarcane belt of northern

1. Census of Pakistan.

2. *Statistical Bulletin No.* 12, December 1963, Vol. 11 p. 225.

3. This as compared to the white sugar consumption in other countries is very low. It is 1/20th of U.S.A. and1/4th to that in Turkey, but in West Pakistan Gur and Desi sugar is also consumed in substantial quantities specially in the rural areas. Therefore the consumption of all types of sugar per capita turns out to be about 38 lbs. including the imported sugar.

India, but the overall progress of the industry was slow and the imports of refined sugar operated to the detriment of the industry within the country. The Indian sub-continent could not compete with the tropical countries becasue of inferior varieties of low yielding sugar-cane. The discovery that sugarcane can produce viable seeds in certain parts of southern India and the Indian Sugarcane Act of 1920[1] gave some impetus to the industry. 'The Sugar Industry Projection Act' of 1932 and the development at Coimbatore of new sugarcane varieties suitable for the climate of northern India were two other landmarks in the development of this industry in the sub-continent.

By 1946-47, there were 135 sugar factories operating in the country mostly located in Bihar and U. P. provinces. The two wings of Pakistan, placed at the two extremities of the Sugarcane belt of Northern India, inherited only 8 of these mills, two in West Pakistan and six in East Pakistan. This was mainly due to limited cultivation of the cane and difficulties of transport for this bulky commodity but partly to the lack of initiative and capital for industrial development in these Muslim majority areas.

West Pakistan was, therefore, badly deficit in the production of white sugar, only 1.8 lbs. per capita annually (1·1 lbs. per capita in East Pakistan and 1.5 lbs per capita in West Pakistan). The production of sugar from the two sugar mills was 793 tons only in 1947-48 against an installed capacity of 11,000 tons annually.

The Industry during the post-partition period from 1947-48 to 1954-1955

During this period, the industry made some progress. The Premier Sugar Mills and Distillery at Mardan, which was under construction at the time of independence was completed in 1950 with an installed annual capacity of 3500 tons. The existing capacity of the Takhti-Bahi Sugar Mills was increased by about 4,000 tons.

In 1954, the P.I.D.C.[2] set up a Sugar Mill at Jauharabad (which was later named as Kohinoor Sugar Mills Ltd) in the irrigated areas of Thal. During the same period the Thal Development Authority established one sugar mill at Leiah in Muzaffargarh district. With these five sugar mills the total annual installed capacity increased to 70,000 tons distributed as follows :

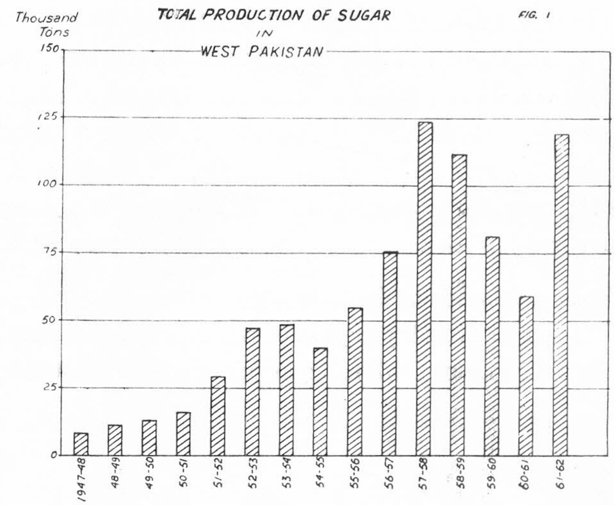
		Annual capacity (tons)
1.	The Frontier Sugar Mills, Takhti-Bhai	6000
	Extension plant of Frontier Sugar Mills	4000
2.	Rahwali Cooperative Sugar Mills, Gujranwala	5000
3.	The Premier Sugar Mills, Mardan	35000
4.	Kohinoor Sugar Mills Ltd., Jauharabad	10000
5.	The Leiah Sugar Mills Ltd. Leiah.	10000
	Total : ..	70000

1. Report of the Pakistan Sugar Commission, 1957, 59.
2. Pakistan Industrial Corporation established in January, 1952.

None of these mills worked to full capacity, with the result that the production during 1954-55 was only 40,211 tons, about 57% of the installed capacity. However, in spite of this the production of white sugar in West Pakistan had increased five fold since 1947-48 (Fig. 1).

The Industry during 1955-56- 1959-60

The sugar industry showed a much more rapid progress during these five years, the period of the First Five Year Plan. This industry was given great priority in the programme of industrial development. The plan provided for the increase of sugar production to 2,35,00 tons in Pakistan to be undertaken by P. I. D. C. and the private sector partly by providing additional capacity to the existing mills and partly by adding new mills especially in the central and southern regions. The special feature of the plan was to provide large sugarcane farms of at least 6000 acres for each of the new mills. About Rs. 12.0 m. were sanctioned for the modernization and Rs. 226 m. for increasing the capacity of the existing mills.



The only mill that was established in this period was the Charsaddah Sugar Mills Ltd. at Charsadda, in 1956 with a total capacity of about 15,000 tons. Another 5,000 tons capacity beet sugar plant was added to this mill in 1958.

During this period the sugar production more than doubled (See fig. 1 and Table 1). The marked rise in sugar production during 1957-58 and 1958-59 was mainly due to the exceptionally long crushing season of 175 days and milder winters free of heavy frost, which does great damage to the sugarcane crop. The peak production of 123,697 tons was recorded in 1957-58 when all the six mills produced much beyond their installed capacity. The production, however, was again lowered in 1959-60 due to the lesser quantities of cane crushed due to the damage done by frost and pests and a low recovery percentage of 7.4[1] against the possible normal recovery of 9.5%.[2] On the whole the progress, during this period was satisfactory but the P.I.D.C. failed to develop the planned production capacity.

The Industry during 1960-61—1963-64

The Second Five Year Plan laid a target of 300,000 tons of sugar to be produced in both the wings of the country. So far West Pakistan was producing 66% of all the sugar

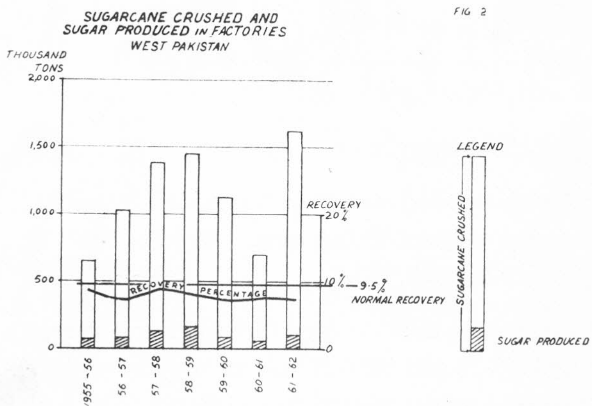
1. Annual Bulletin of Food Statistics 1963—Food Deptt. Pakistan Lahore.
2. Report of the Indian Sugar Committee—Simla Government of India 1921, p. 251.

of the country to maintain the balance it was proposed that both wings should share the total production capacity of the country equally.

From 1960 to 1963 four more milling units were established; namely, The Crescent Sugar Mills and Distillery at Lyallpur, The Fauji Sugar Mills Ltd. at Tando Mohammad Khan (in Hyderabad district), K. B. Industries Ltd. Okara and Ahmer Sugar Mills at Manga Mandi in Montgomery and Lahore districts respectively. Despite the installed added capacity, the production of white sugar in West Pakistan went so low that the total production in 1960-61 was only 59,335 tons—lowest since 1955-56 and about half of that in 1958-59. This was due to the small quantities of cane crushed in almost all the mills and a low recovery rate of 7.5% on account of reasons mentioned above. In 1961-62 the production showed a marked recovery (see fig. 2). Figures for 1962-63 show an increase of about 85% over the previous year. This was primarily due to the increased production from the newly established mills at Lyallpur and Tando Mohammad Khan.

Present Position of the Industry

The overall progress of the industry since independence is evident from the fact that the production of white sugar per capita in West Pakistan has increased from 1.8 lbs. to 5.7 lbs between 1947-48 and 1961-62 despite the increase in population by 33.8% between 1951—1961. A detailed analysis shows that only two areas of Peshawar—D. I. Khan divisions and Lahore—Rawalpindi divisions produce more than 5 lbs. of sugar per capita per annum, Khairpur, Hyderabad divisions produce very small quantities. This level of production is far from satisfactory. The estimated requirements of white sugar at the existing rationed rates[1] were about 3,50,000 tons for the population in 1961 which has now increased, and the projected demand is estimated to be 5,00,000 tons of white sugar by 1965. The past trends of progress show that self- sufficiency in this respect is as yet far off. Due to the large scale production of Gur and Desi Sugars amounting 36.5 lbs. per capita, the shortage of Sugar has become less acute. (Table 2). Given 10% for other sugar consuming industries about 36 lbs. of all sugars and gur are available from local sources (excluding imported sugar). This, according to Dr. Kykroyd's[2] estimates of a minimum of 2.3 ounces of sugar per capita per day or 52 lbs. per capita annually, is deficit by about 16 lbs. This condition



1. 24 lbs. per capita per annum for the urban and 6 lbs. per capita per annum for the rural population.
2. Pakistan Sugar Commission, pp. 4

necessitates imports of white sugar. The share of imported sugar in the consumption of white sugar is much higher in Karachi, Hyderabad and Quetta regions, which produce very little sugar of their own (Fig. 3).

Raw materials of the Industry

Sugarcane is the basic raw material covering about 62% of the cost of sugar production. In West Pakistan, 96.3% of the sugar is produced from sugarcane. Like the sugar industry in other parts of the world, the industry in this country is oriented to this basic raw material. In West Pakistan, about 11,00,000 acres are under sugarcane which covers 4.7%

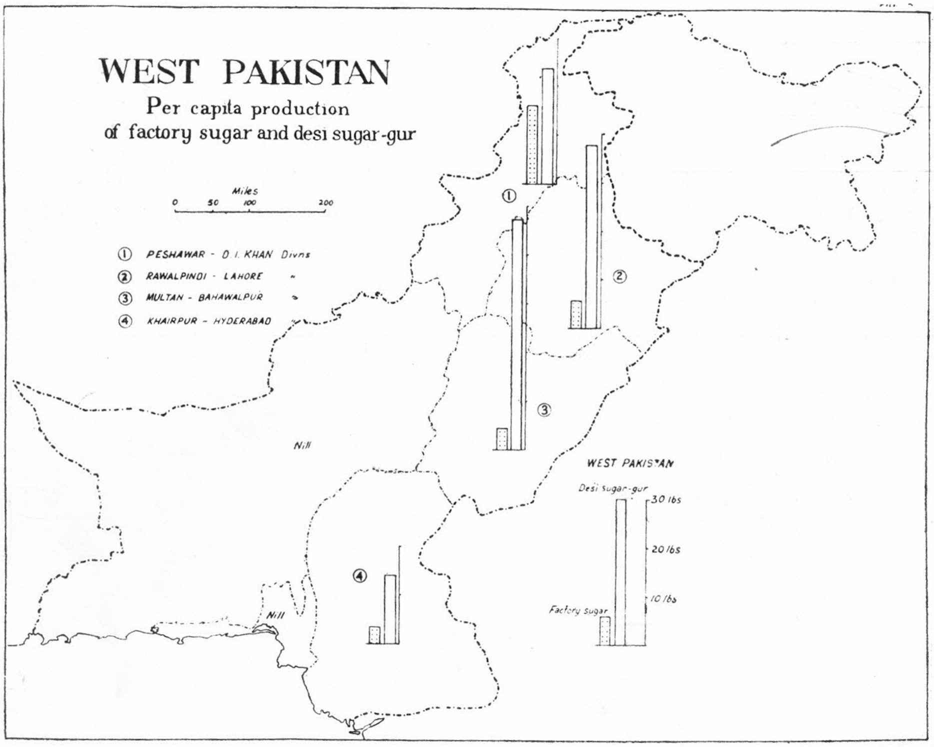


Fig. 3

of the total sown area. Fig. 4 reveals that the area under sugarcane has increased more than 100% since 1947-48. This is due to the growing demand for *Gur* and *Desi* sugars at attractive prices and the extension of irrigation by the newly constructed canals in the Lower Indus Basin. In spite of this large scale production of sugarcane only about 10.4% of the total produced is consumed in the manufacture of white sugar.

Climatically speaking West Pakistan is not ideally suited for the cultivation of sugarcane. Being a tropical crop it grows best in areas with equable high temperature, free of frost, plenty of sunshine, well distributed rainfal between 50″—100″, high humidity and a dry season at the ripening stage. In West Pakistan, the great seasonal range of temperature and the occurence of severe winter frost in the northern regions are detrimental to high yields.

Moreover, the rainfall is too meagre for the crop to grow without irrigation. This deficiency of water is, however, made up by canal irrigation. All the sugarcane grown in West Pakistan is irrigated. The southern regions, which are free from winter frost, are relatively better suited to this crop. This is reflected in higher yields, in Hyderabad region as compared to the Peshawar region.[1]

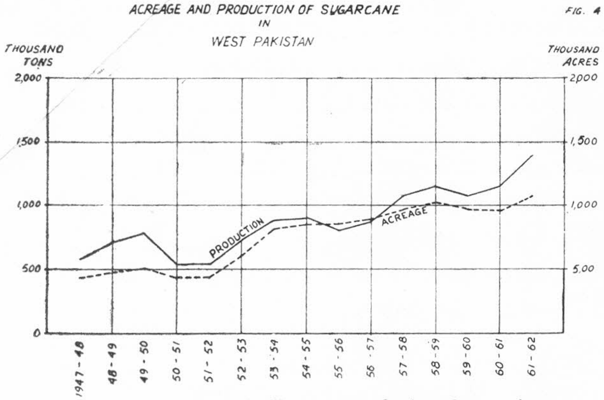
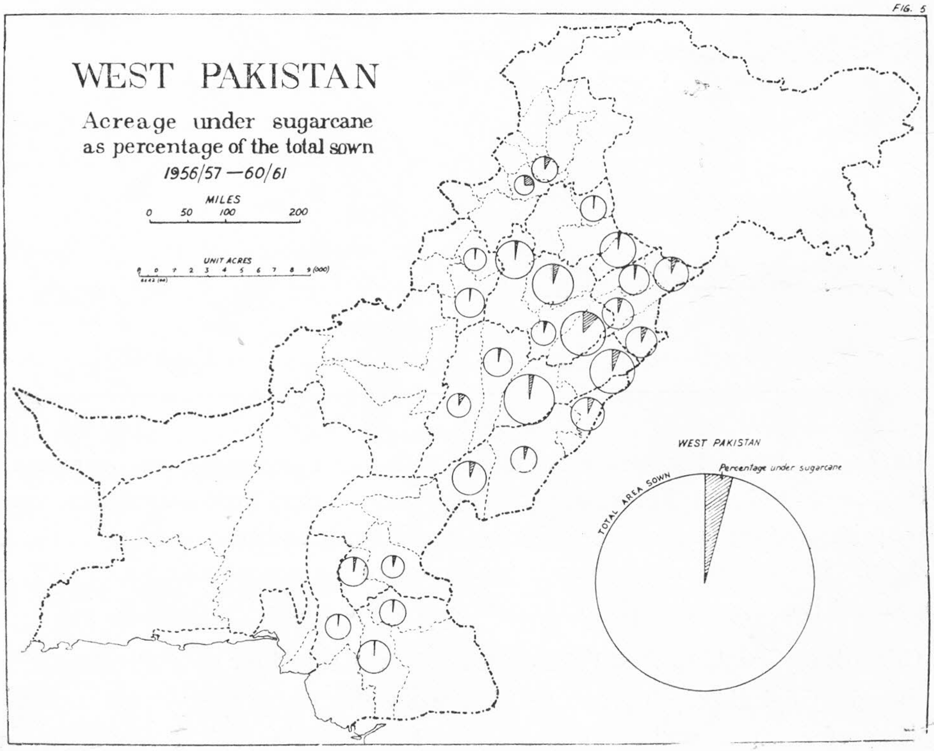


Fig. 5 shows the relative importance of sugarcane in various districts of West Pakistan. The frontier districts of Peshawar and Mardan form the main trans-Indus sugarcane belt in the north where 24.2 and 9.3%[2] of the total sown area is under sugarcane respectively in spite of heavy winter frost. It is associated with the extension of canal irrigation in this area and the influence of the factories.

The second sugarcance belt stretches from Sialkot district in the northeast to Rahimyar Khan district in the southwest. The greatest concentration is in Lyallpur district

FIG. 5



1. 424 maunds per acre in Hyderabad and 309 maunds per acre in Peshawar Region.
2. Calculated on the basis of Figures for 1961 62.

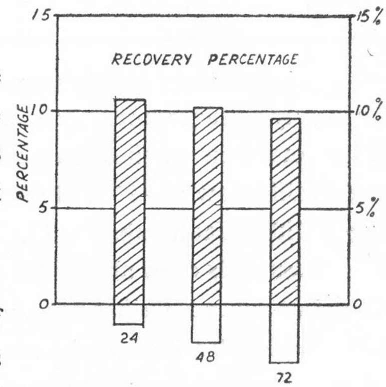
where 11.5% of the sown area is under this crop. The third sugarcane belt is in Khairpur division, centered round Khairpur and Nawabshah districts.

Sugarcane is a bulky product and its long distance transport proves costly. The sugar factories, therefore, have to be located in the midst of sugarcane growing areas. There a sure supply of sugarcane is possible during the crushing season from within a distance of 10-15 miles of the factory.

Experiments at Rahwali Sugar Mills have shown that the sugar content in the sugarcane is adversely affected by the time lag between harvesting and crushing and is inversely proportionate. Fig. 6 shows the association between these. If the harvested cane is crushed within 24 hours the recovery percentage is as high as 10.6%. It drops to 10.2% with a time lag of 48 hours and to 9.7 % with a time lag of 72 hours. The recovery percentage and consequently the sugar production is inversely proportionate to the time lag between harvesting and crushing.

FIG. 6

RELATIONSHIP BETWEEN TIME LAG AND RECOVERY PERCETAGE



TIME LAG IN HOURS

The above factors show how essential it is for the sugar factories to be located in areas where sugarcane production is concentrated. This further lays emphasis on the need of a quick and effcient means of transport to reduce the losses of sugar due to time lag.

Zoning system for the Sugar Mills

To overcome the difficulty of regular supply of sugarcane within the shortest time, a zoning system was adopted in 1950 in the Frontier Regions when the Premier Sugar Mills went into production. It was later on modified and applied to other mills in the region. According to this system, four zones were demarcated and the percentage of cane to be lifted from each zone was fixed. The Premier Sugar Mills was to lift 75% of the sugarcane crop from within a radius of 1—7 miles, marked as zone A, 50% of the crop from zone B within a radius of 7—10 miles, 40% of the crop from zone C within a radius of 10—15 miles, 30% from zone, D, beyond a radius of 15 miles. The Frontier Sugar Mills being smaller could lift 75% of the crop from zone A, within a radius of 1—3 miles, 30% from within zone B within a radius of 3—5 miles, 40% from zone C within a radius of 5—7½ miles.

This system created some difficulties and had to be modified. After the imposition of Martial Law, the entire sugarcane area was declared as Assigned Area for various mills. Two zones were demarcated A and B. The mill was to lift 65% of the cane cropped from zone A and 36% from zone B. In the former Panjab area, no zoning was introduced. The following table shows the actual position regarding sugarcane supply to the various mills in 1958-59[1].

1. Report of Pakistan Sugar Commission, Appendix No. 10.

PROCUREMENT OF SUGAR CANE

	Within 5 miles radius	5—10 miles radius	10—25 miles radius	Beyond miles radius
Premier Sugar Mills	19%	40%	23%	17
Charsadda Sugar Mills	36	25	..	39
Fauji Sugar Mills	37	43	..	20
Rahwali Sugar Mills	49	25	..	26
Kohi Noor Sugar Mills	17	8	18	57
Lieah Sugar Mills	18	9	30	43

These figures clearly show the more favourable location of certain mills as regards the supply of sugarcane. Premier Sugar Mills and Charsadda Sugar Mills draw 60—65% of the total cane crushed from within short distances. Frontier Sugar Mills and Rahwali Sugar Mills draw 70—80% of the total cane crushed from within 10 miles radius. Kohinoor Sugar Mills at Jauharabad and Leiah Sugar Mills are not so favourably located in this respect. Both these mills draw about half the required sugar cane from a distance beyond 25 miles. Kohinoor Sugar Mills has been drawing sugar cane from Sargodha district from a distance between 40—90 miles. Quite often the mill has been using *Gur* as an alternate raw material on account of a shortage of sugarcane supply. Recently a farm of 6260 acres has been attached to the mill to ease out the situation. The worst affected in this respect is Leiah Sugar Mills which had been drawing cane from as far as Mardan (275 miles). It has been reported that this shortage of sugarcane supply has not been due to lack of sugarcane round the mill. The mill's own farm was auctioned on account of bad management, and the private growers use sugar cane more profitably for making Gur and *Desi* Sugar. Crescent Sugar Mills at Lyallpur has no dearth of sugarcane supply and the Fauji Sugar Mills at Tando Mohammad Khan has a large farm attached to it which had made it almost self sufficient in sugarcane requirements.

In 1962-63, the Government in its sugar policy considered the zoning system necessary for all those mills which did not have their own farms on the pattern discussed earlier. The zoning system in particular and the establishment of sugar mills in general, has changed the pattern of land use in areas round the mills. In Peshawar regions in the vicnity of Premier and Frontier Sugar Mills the concentration of sugarcane is reflected in the high ratio[1] of sown area under this crop.

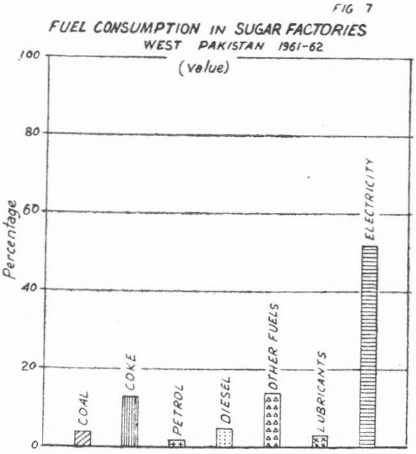
13. 40% in some villages round the mill. Cansus of Agriculture, 1961.

Sugar Beet. Until recently all sugar in the factories was produced from sugarcane. Recent experiments carried out in the Peshawar valley have shown that sugar beet can be successfully grown in this area. The climate in this region is such that the sugarcane crop suffers heavy losses on account of severe winter frosts. Beet is successfully cultivated in areas with mean temperature between 62—65° F. with plenty of water supply and sunshine and dry weather during the ripening period. Such conditions of temperature are present during winters in the Peshawar valley. Here the sugar beet is sown in September-October and harvested in May and June. This prolongs the crushing season. It yields a higher amount of sugar per acre, and its cost of production is lower than that of sugarcane. Trials are being made to develop seed in this region, which would save a foreign exchange of Rs. 125,000 annually. Only Charsadda Sugar Mills has added a sugar beet plant and regularly produces sugar from beet sugar since 1958—59. It is expected that sugar beet cultivation may extend further. It would render sugar production more economical in the northern region of Peshawar division.

Fuels Consumed

Sugar manufacturing industry does not place a very heavy demand on fuel. The overall consumption of the various fuels is given in Fig. 7 and table 3. Cost of fuels accounts for 10—12%[1] of the total cost of manufacturing white sugar. The relative importance of various fuels depends on the availability of these at relatively low costs at different places. More than half the total cost of fuels is covered by electricity both thermal and hydroelectric. The mills that depend mostly on electricity are Frontier Sugar Mills, Premier Sugar Mills Mills, Crescent Sugar Mills, Leiah Sugar Mills and Fauji Sugar Mills. The last two have thermal electricity (Table 3).

FIG 7



The next important source of fuel is coal and coke, which cover 16.7% of the total cost of fuels. Kohinoor Sugar Mills depends for 45% of its fuel on coal and coke. Rahwali Sugar Mills and the newly set mill at Okara depend mostly on firewood.

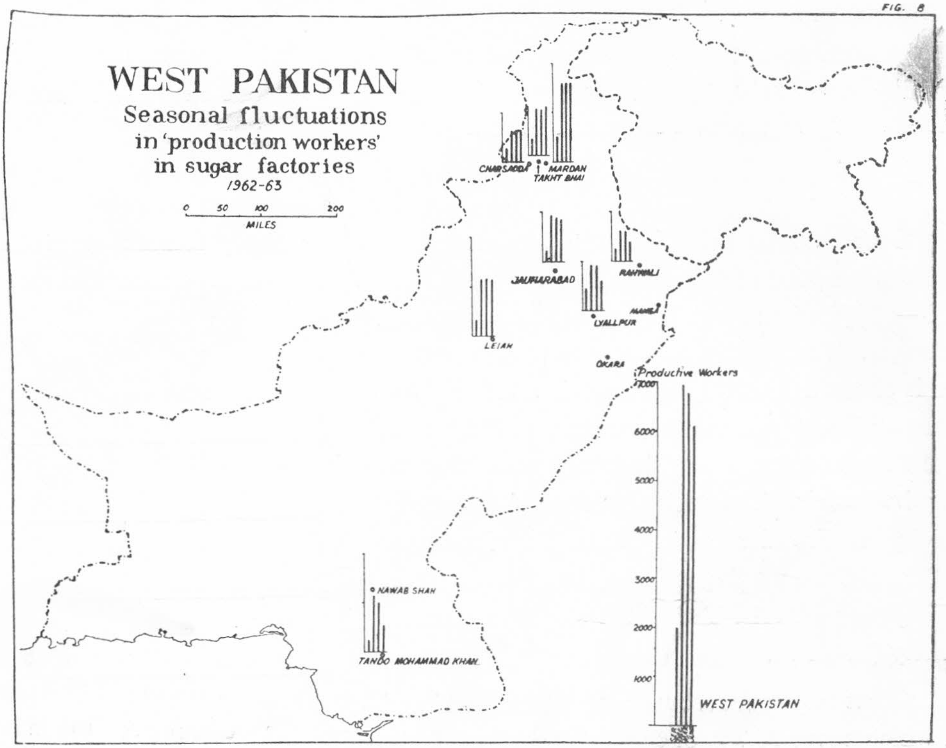
Labour Supply

In West Pakistan, on the whole, there is no dearth of labour supply as this industry does not place a great demand on the skilled labour. The nature of the industry is such that a year round crushing season is not possible as long as sugarcane remains the basic raw material. The seasonal nature of the industry is reflected in the great seasonal differences

1. Report of the Pakistan Sugar Commission, p. 71.

in the production of labour force (Fig. 8). In September, 1962, the total number of production workers was only 2103 , but from December to March the number increased to about 7000. By June, 1963, when the crushing season was over the number dropped to about 6000. The average crushing season is normally calculated to be of 150 days in West Pakistan. The commencement and the end of the crushing season varies from factory to factory and year to year depending on the temperature conditions that affect the crop in general and the sucrose content of sugarcane in particular. The crushing season begins earlier in the southern regions and also finishes earlier on account of early ripening of cane. A comparison between the sugar seasons at Fauji Sugar Mills, and Frontier Sugar Mills clearly reveals this fact. At the Fauji Sugar Mills at Tando Mohammad Khan in the southern region,

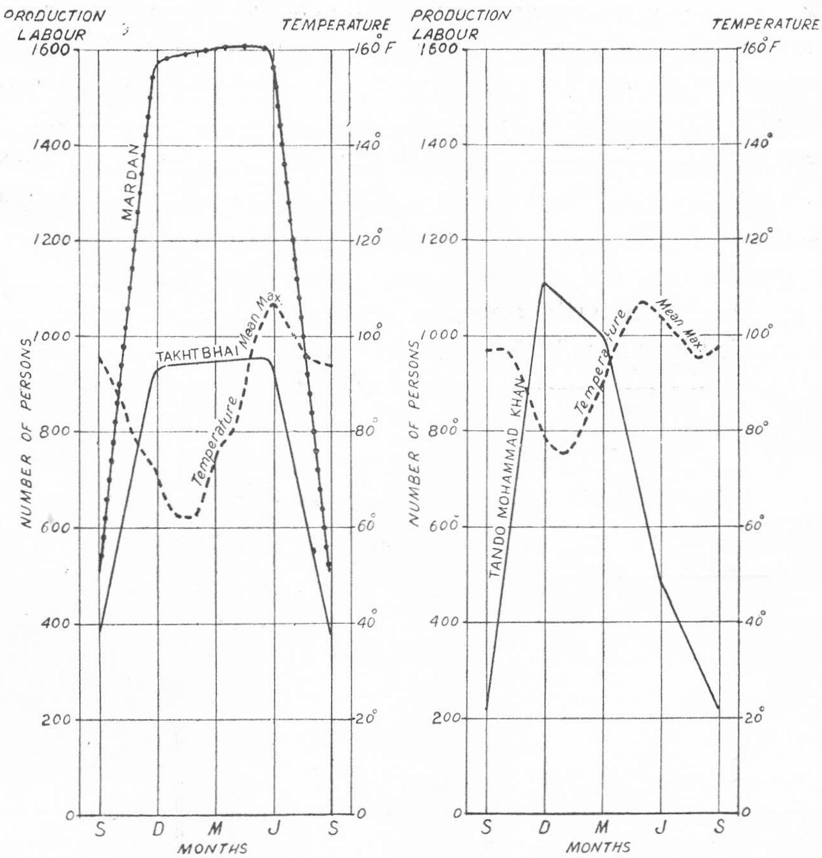
FIG. 8



the mean maximum temperature in October and November is higher than in the north at Takhti-Bhai by about 9° and 15° F respectively; therefore, the cane ripens earlier and the crushing season commences by the last week of October and ends by mid April. In the Takhti Bhai Sugar Mills in the north, the crushing season begins by the end of November and lasts till middle of May. The rise of temperature in April and May is more marked in the south, which reduces the sucrose content of the sugarcane and, therefore, leads to early ending of the crushing season. Both these trends are shown in Fig. IX. The sugar mills at Leiah and Jauharabad do not show an early begining and ending of the crushing season. This is due to the lack of sufficient supply of sugarcane for the crushing. There has been a great competition between these mills and the growers for the consumption of sugarcane. The growers like to manufacture *Gur* which is more paying. This delays the functioning of the mill and hence quite often the crushing season is prolonged due to a late start.

FIG. 9

SEASONAL FLUCTUATION IN PRODUCTION LABOUR



Important Centres of the Industry

There are ten centres of the industry in the whole West Pakistan. These are very unevenly placed as far as their distribution is concerned. Three centres of the industry in the Peshawar Region are within short distances of each other, while the centres in Lahore region show a more even distribution. The southern areas of Multan, Bahawalpur, Khairpur and Hyderabad divisions have only two mills.1 The importance of some of these centres in discussed.

Sugar Mills in the Peshawar and D. I. Khan Divisions

This area has 13.5% of the total cane acreage and utilizes 40.5 % of the total crop for the manufacture of white sugar. There are three centres of the industry-Takhti Bhai,

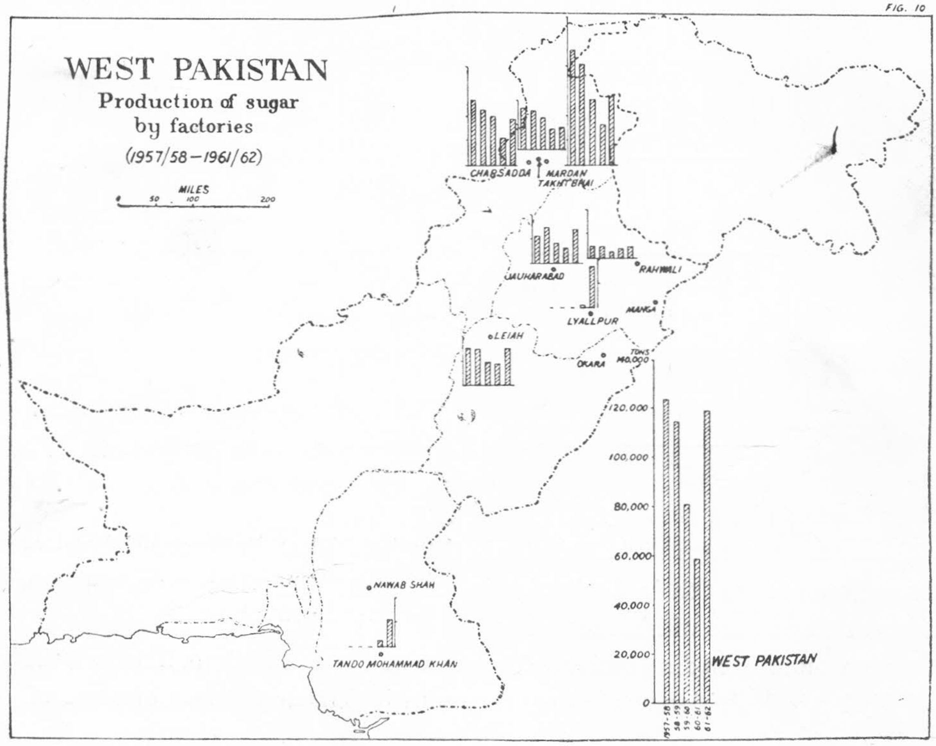
1. Recently one more sugar mill has been set up in Nawab Shah.

Mardan and Charsadda with one sugar mill each. These three mills produce 48.0% of the total sugar of West Pakistan. All these sugar mills show great fluctuations in production from year to year. This is mainly due to the area being frequently subject to heavy winter frosts, which damage the sugar cane crop and reduce the recovery percentage.

The Frontier Sugar Mills Takhti Bhai

The mill was installed in 1938-39. The present capacity is 10,000 tons of sugar annually. Its further extension is contemplated. The production from this mill has undergone violent fluctuations between 8,000 tons to 1792 tons in the past few years. The low production in 1960-61 and 1961-62 (see Map 10) was mostly due to lesser quantities of cane crushed and a low recovery percentage between 5—7%[1] on account of heavy winter frosts that damaged the sugarcane crop. The Mill employs about 700 persons during the slack season from June to September, but the number increases to about 1500 during the crushing season. The Mill is favourably located regarding the supply of sugarcane and can procure plenty of sugarcane from within a radius of 10 miles It also has the advantage of cheap hydroelectric power from Malakand.

FIG. 10

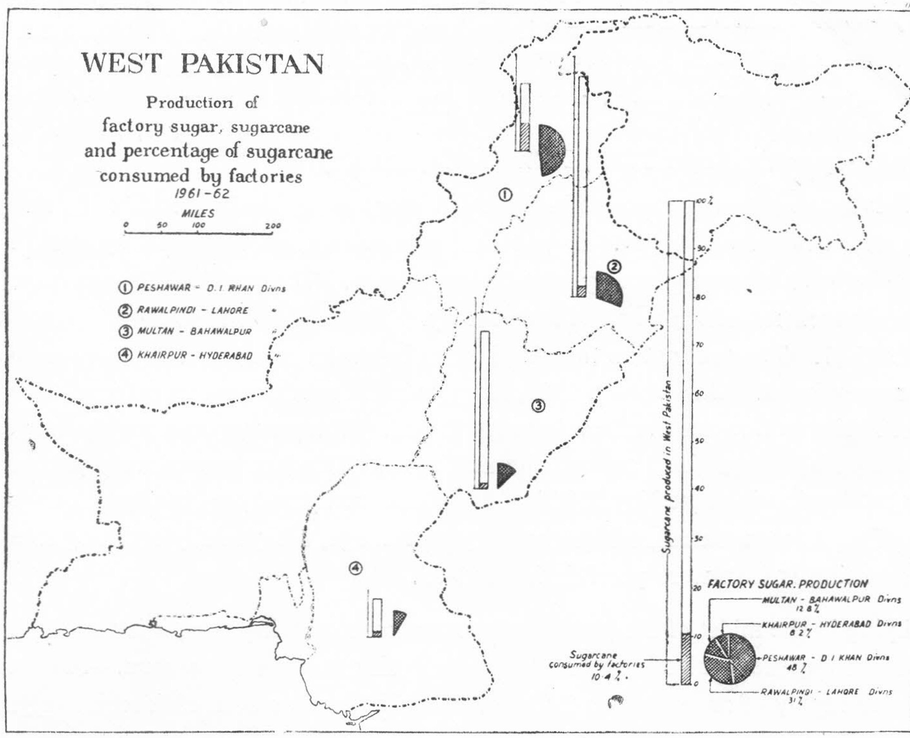


Premier Sugar Mills, Mardan

This is the largest sugar mill in Pakistan with a total annual production capacity of 35,000 tons. It employs about 1118 persons in the slack season, but the number increases

1. Annual Bulletin of Food Statistics 62, 63, Food Department, West Pakistan, Lahore.

to 2200 in the crushing season. It went into productionin 1950-51. During 1957-58 the mill produced more sugar than its capacity on account of milder winters which prolonged the crushing season. On the other hand the production in 1960-61 and 1961-62 shows low trends on account of winter frosts. (Fig. 11).



The Charsadda Sugar Mills, Charsadda

This mill was set up in 1956 by the P. I. D. C. with an annual capacity of 15,000 tons of sugar production and a provision for extension. The production, in keeping with the general overall conditions in the region, was low during 1960-61 and 1961-62.

About 500 persons work during the slack season and 1200 during the crushing period. The mill has its own farm of about 4500 acres where higher yields of sugarcane, upto 350 maunds ($1\frac{1}{2}$ times the average in the country), are obtained.

The mill was the first to produce sugar from sugar beet in 1958-59. A sugar beet plant has been added with a daily crushing capacity of 1000 tons. The experiments in sugar beet cultivation, as has been referred to earlier, have been quite encouraging. The foreign experts who visited the mill farm were surprised to see the successful crop of sugar beet. The mill produced about 4,000 tons of beet sugar in 1961-62.

Sugar Mills in Lahore and Rawalpindi Divisions

There are five centres of the industry in this area-one each at Rahwali, Lyallpur, Jauharabad, Manga Mandi and Okara. In this area 5.5% of the sown acreage is under sugarcane. It produces 46% of the sugarcane and 31% of the sugar of West Pakistan which amounts to 5.2. lbs. of sugar per capita.

There is room for more units to be set up in this area as until now it has only utilized 4.6% of the total sugarcane that is produced for the production of white sugar. With milder winters in most parts of the region, the sugarcane crop is less subject to frost damages and the crushing season is relatively longer.

Rahwali Co-operative Sugar Mills, Rahwali (Gujranwala)

This is the oldest sugar mills in West Pakistan, established in 1936, with an annual capacity of 5'000 tons of sugar. It was formerly owned and managed by non-Muslims and was declared evacuee property after independence. The provincial government took over its management which was not satisfactory. The mill only functioned intermittantly during 1945-47. The production remained much below its productive capacity on account of bad management. On 1st July, 1962, the provincial government transferred the mill to the West Pakistan Cooperative Development Board. Many sugarcane supply cooperative soceities were also organized around the mill zone. This has proved very encouraging, and the production increased by 50% in 1962-63 as compared to the previous season. Due to efficient management, a high recovery percentage, a high daily crushing rate and a longer crushing season were possible in 1962-63.

Lying in the midst of the good quality sugarcane growing area, it is very favourably located regarding the regular supply of sugarcane during the crushing season. For the quick and regular supply of sugarcane to the mill, the mill zone has been divided into eight sub-zones and almost all the cane is drawn from the zone area in such a way that on a particular day, the supply comes from one or at the most two sub-zones shown in Fig. 12.

Crescent Sugar Mills, Lyallpur

This mill has been recently installed and has a daily crushing capacity of 1500 tons of sugarcane. It produced 932 and 16,826 tons of sugar in 1960-61 and 1961-62 respectively. The crushing season begins in the third week of November and ends by the last week of April or beginning of May. The recovery percentage is supposed to improve in future with the mills efficient working. It employs between 500—1100 people during the slack and crushing season respectively.

The mill is ideally located as regards sugar cane supply, fuel and market. Lyallpur district has 11.5 per cent of its sown area under sugarcane. This is the highest ratio, after Peshawar district, in whole of West Pakistan. Lyallpur district has been a very important sugarcane producer even during the pre-partition time, but unfortunately no sugar mill was established here. About 2/3 of the fuel cost is covered by electricity. In the near future it shall enjoy the cheap fuel of natural gas from Sui.

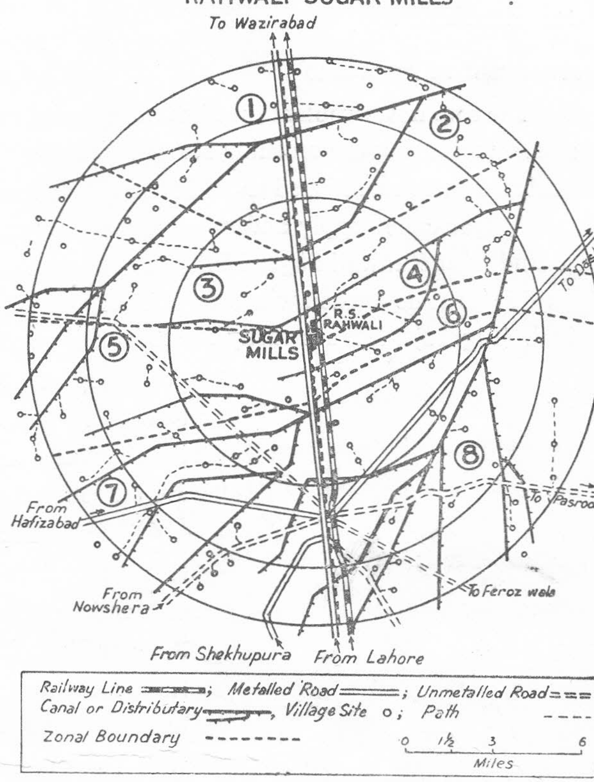
Kohi Noor Sugar Mills, Jauharabad

It was set up in 1954 by the P. I. D. C. with a total production capacity of 10,000 tons of sugar annually and a provision for further extension. This mill was originally designed to cater for the needs of Sargodha division. The mill, however, was not favourably located as regards sugar cane supply. In the first instance there is no great concentration of sugarcane in the area round the mill and secondly there has been a keen competition between the white sugar and *gur* making. It has been discussed earlier that the mill had to draw a greater portion of the total cane crushed from beyond 15 miles, which factor alone rendered the functioning uneconomic. Plans have been made to ease out the raw material situation, and a farm of about 6200 acres has been attached to the mill of which about 1/3rd remains under sugar cane each year. The area is rapidly becoming waterlogged and no further extension of the mill is expected.

Two more mills were established in 1962-63 in this area, one in Manga Mandi (Lahore)and the other in Okara (Montgomery), but the production from these two units is at present small.

FIG. 12

CANE SUB ZONES
RAHWALI SUGAR MILLS



The Sugar Mills in Bahawalpur, Multan Divisions

This area produces only 4.3 lbs. of sugar per capita from only one factory at Leiah, which has an annual capacity of 15,000 tons of sugar. The region has about 3.4% of its sown area under sugarcane and grows about 1/3 of the total sugarcane of West Pakistan. The factory at Leiah (Muzaffargarh district) in the Trans-Indus zone was set up by Thal Development Authority in 1954. The mill originally was attached to a farm of 6000 acres which was later on leased to the growers. It shows great fluctuations in the quantity of sugar produced on account of difficulties of sugarcane supply to the mill. The area round the mill grows plenty of sugarcane which is more profitably used for making *Gur* and *Knand desi*. The difficulty of procuring sugarcane has been so great that the mill has been using Gur for the manufuacture of sugar which had proved costlier. Due to this factor further extension of this mill is not advisable until the regular supply of sugarcane may be ensured from the nearby areas.

Sugar Mills in the Khairpur and Hyderabad divisions

There are two sugar mills in this southern region, one at Tando Mohammad Khan near Hyderabad and the other at Nawabshah (very recently established). The Fauji Sugar Mills at Tando Mohd Khan was established in 1960-61 in order to supply sugar to the southern region, which formerly used all its sugarcane for making *Gur* and *Desi* sugar. The factory is located in Hyderabad district, which at present has only 1.1% of its sown area under sugarcane. In order to ensure the sugarcane supply to the factory, the mill has developed its own farm of about 20,000 acres. The factory has a daily crushing capacity of 1500 tons. It employs about 650 people in the slack season and about 1600 during the crushing season; all of these are ex-military men.

Problems

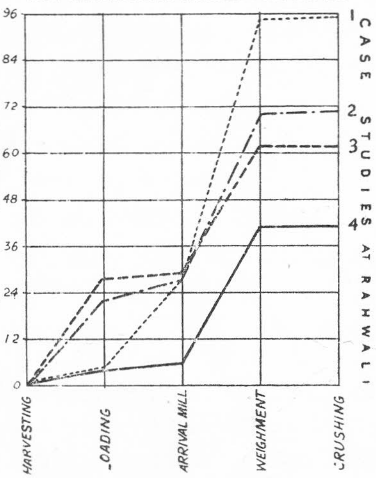
The sugar industry is a socio-economic industry. Many handicaps which at present result in uneconomic functioning of the mills can be removed by efficient management and better planning.

Procurement of sugarcane

The foremost problem that has been facing the mills is the regular and quick supply of sugarcane during the crushing season. The Pakistan Sugar Commission recommended that all new mills established should have their own farms. This may partly solve the problem of sugar cane supply and may reduce the time lag between harvesting and crushing. Case studies at Rahwali Sugar Mills have shown that in most of the cases the greatest time lag is due to time wasted when sugarcane is kept waiting at the factory gate after arrival. (Fig. 13). This is partly due to lack of good management. Lack of efficient means of transport also contributes a great deal to this time lag. Apart from the approach roads, most of the roads serving the sugarcane areas around the mills are unmetalled and present great transport difficulties.

FIG. 13

TIME LAG BETWEEN HARVESTING & CRUSHING



The greater concentration of sugarcane cultivation around factories would also help in more economic transport by trolly lines. This is done at Premier Sugar Mills from within a distance of 10 miles. In the Rahwali Sugar Mills most of the cane is brought to the factory gate by trucks and carts from within short distances. In a few cases, such as Leiah and Jauharabad, railways are also used as a means of transport for sugarcane. The mills with their own farms can easily overcome this difficulty by mechanized transport of their own. For other factories, cooperative transport societies can help to solve this problem. Another aspect of procurement of sugarcane is the competition offered by growers for making *Gur*. *Gur* and *Khandsari* making, as has been stated, proves to be more economic than selling sugarcane to the mill. In view of this difficulty, the Government has fixed the prices of sugarcane between Rs. 1.75 to 2.25 per maund for different varieties and has banned the manufacture of *Khandsari* within the mill zone.

Yields of Sugar

The other problem is of low yields of sugarcane. The average yield of sugarcane per acre in Pakistan is about 1/5 of that in Hawaii and about 1/4 of that in Java. This is partly accounted for by the climatic factors. A short growing season and severe winter frosts in the northern regions are partly responsible for the low yields. In the southern regions where winters are mild, low yilelds are more on account of general lack of Scientific approach and insufficient use of fertilizer than due to any other factor. Many factories like the Premier Sugar Mills at Mardan, Frontier Sugar Mills at Takhti Bhai and the Charsadda Sugar Mills have been suffering losses due to damages done to sugarcane by frost and pests. No suitable frost variety has been evolved as yet. As regards pests and diseases, chemical sprays have proved helpful for the farmers in keeping them under control.

However, experiments have shown that the per acre yield of sugarcane is much higher, almost one and a half times as large, on the factory farms than on private sugarcane fields. This clearly shows the importance of efficient management and the coordination between the field and the factory. Due to the various problems mentioned above, the price of sugar manufactured in Pakistan is higher than the price of imported sugar (Report of the Pakistan Sugar Commission, p. 73). This can be brought down by various measures suggested above.

Planning for the future

As shown in table 2, all West Pakistan is deficient in white sugar production, according to the existing ration rates. This deficiency is made up by imports of white sugar, the share of imports decreases with increasing distance from Karachi. The only region that has surplus to offer is the Peshawar and D. I. Khan divisions. This means that the central and the southern regions should have a greater share in the future share of sugar mills. The extension of the existing mills in the Peshawar region is also contemplated on the basis of sugar beet cultivation. As has been referred to earlier, a beet sugar plant has already been added to Charsadda Sugar Mills. This means an extension of the crushing period. It also brightens the future prospects of the industry in the region where sugarcane is often badly hit by frost.

At present the north-western regions of Peshawar and D. I. Khan divisions utilize 40.5% of the total cane produced in the region for the manufacture of white sugr. The rest of the sugarcane is utilised for making *Gur* and *Khandsari*. The Lahore-Rawalpindi divisions produce 46% of the total cane of West Pakistan but use only 4.6% of the total for the manufacture of sugar, whereas Bahawalpur-Multan divisions with about 1/3 of total sugarcane crop of West Pakistan only use 3.5% in the factories. The rest is mostly used for making *Gur* and *Khandsari*. The condition in the southern regions formerly was worse but with the installation of Fauji Sugar Mills at Tando Mohammad Khan, it now utilizes 13% of the total sugarcane of the region for milling. These figures suggest that the central and southern regions should have many more sugar mills as sugegested by the Pakistan Sugar Commission. Each of these units should be medium sized with an annual capacity of 15,000 tons of white sugar. All these should have their own farms of 20,000 acres which should render the mill self-sufficient in the requirements of sugarcane. Sialkot and Sheikhupura districts with 6.6, and 5.5% of the sown area under cane, are suitable areas for further installaation of sugar mills. Bhawalpur, Multan, Bahawalnagar and Rahim Yar Khan districts, with plenty of sugarcane production, are suitable areas for the location of sugar mills.

There will, however, be no dearth of power for these mills as the southern and central regions will have the facilities of the cheap power supplied by Sui Gas, whereas the northern regions have plently of water power for running the factries. Moreover, there is no dearth of industrial labour in any of these regions. The case for the installation of new sugar mills is strengthend on the basis of existing small production of sugar and large quantities of sugarcane available. Climatically also these regions are more suited to sugarcane cultivation. The milder winters eliminate the danger of frost that is a great enemy of the sugarcane crop in the northern regions. Moreover, the early ripening of cane and an early commencement and ending of the crushing season leaves the ratooned crop of sugarcane to sprout again in April and May or leaves the field clear for the next crop to follow. The useful research being done at the sugar research centres at Lyallpur, Mardan and Murree would also be of great help in evolving new, better yielding varieties with greater environmental resistance. A comparative study of the statistics for the sugar production and sugar imports of West Pakistan shows that despite the larger production of white sugar, the imports have risen. This is due to the population increase, greater urbanisation and better standards of living. The future developments in the sugar industry would go a long way in saving a foreign exchange of about 30—40 million rupees for West Pakistan alone which shares about 76% of the sugar imports of the country.

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CITIES OF THE UPPER INDO-GANGETIC PLAIN

BY

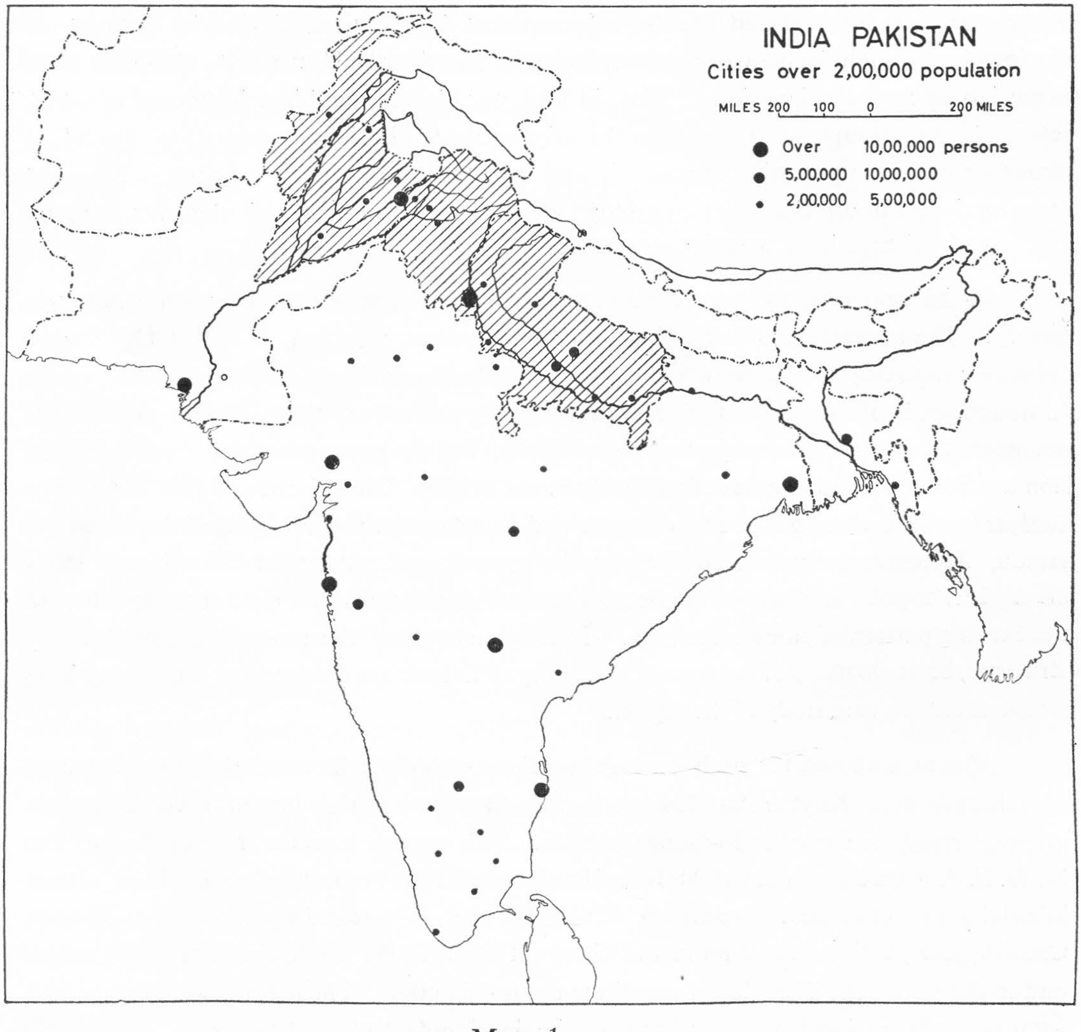
RASHID A. MALIK

The history of the Upper Indo-Gangetic plain has left strong impress on the pattern and character of cities that lie in this region. Their morphology and structure are reminiscent of the cultures that penetrated into the sub-continent in the past. Lying in the path of any invader through the passes on the northwestern frontier, the Upper Indo-Gangetic plain exprerienced frequent invasions. This, in fact, was the thoroughfare by means of which several culture groups penetrated into the subcontinent. Each early migration has left a strong impression upon the functional, and geometric pattern of the cities. Thus, the cities of the plain are the result of a long period of evolution in which elements of many creeds and cultures have been incorporated.

In the Upper Indo-Gangetic plain, urbanism as a mode of life has existed since early history. The excavations of cities, such as Mohenjodaro, Harappa, and Kot Diji Taxila, indicate a high degree of urbanization in the Indus Valley dating as far back as 4,500 years. Although study of these ancient cities would be of great value, the available space does not permit to discuss the subject at such a length. For the purposes of this paper, discussion has been confined to cities of relatively recent origin. The objective of this study is to analyse the basic elements of city structure and to determine the influence of the successive Hindu, Moslem and English cultures on the growth and pattern of cities in the study area. It is hoped the paper will indicate historical associations that have come to establish the existing pattern of cities in the area. To fully understand the mosaic of complex city structure, basic elements of settlement in the city of Lahore are discussed at some length as a representative case study of the region.

The area chosen for study encloses portions of both India and Pakistan. The land stretching from the Khyber Pass down to Vanarsi (Benaras) on the Jumna River is, in this paper, termed the Upper Indo-Gangetic plain. This area encloses the former Panjab and N. W. F. P. in Pakistan and the States of Panjab and Uttar Pardesh in India. It is a vast alluvial plain, climatically speaking semi-arid, and is watered by the Indus, Jhelum, Chenab, Ravi, Satluj, Beas, Jumna and Ganga Rivers. To the north, the Himalayan ranges and to the south, the Thar desert constitute natural frontiers. The natural and climatic uniformity of this region have contributed to the development of a culture more comparable to near-Eastern countries than the rest of India. The cultural uniformity in the area and the areal and functional likeness in the cities have been two of the reasons for selecting this area.

Another reason for studying the Upper Indo-Gangetic plain is that this is the most highly urbanized region in the sub-continent. The degree to which this area is urbanized can be judged from the fact that, according to 1961 census about 30 percent of the Indian cities of over 200,000 population are located in the Upper Ganges Plain, which constitutes only 13 percent of the total land in India. In Pakistan, the concentration of urban communities in the Upper Indus Plain is of an even more striking nature. It is significant to observe that in 1961 the Upper Indus Plain, which constitutes only 27 per cent of the Pakistan territory, contained over 60 per cent of the cities of over 200,000 population (Map 1).



Map. 1

These percentages will increase if we only consider the inland cities, leaving out four large ports in India and two in Pakistan. Primarily, therefore, the purpose of this paper is to account for the factors, both cultural and physical, which have contributed to form and function of the highly urbainzed settlements in this area.

HISTORICO-GEOGRAPHIC SETTING

The reason for the high degree of urban development in the Upper Indo-Gangetic plain lies in its location and history. On the banks of the holy rivers Ganges and Jumna, various highly developed Hindu kingdoms have emerged. Buddhism flourished in Taxila (West Pakistan) and in the Ganges Valley. The Delhi-Peshawar axis, acting as a highway, brought the Upper Indo-Gangetic Valley into contact with Central Asia, China and Greece. The cultural influence of Buddhism was great, but to-day it can only be traced in ruins and temples long abandoned. The Hindu influence, although greatly modified, can be detected in the existing urban landscape.

The strong cultural impact exerted by the Moslems in this area may also be attributed to its location, since the Delhi-Peshawar axis served as a Moslem marchland along which waves of invasions from the northwest came during the last 1,200 years. Since this area was easily accessible through the Khyber and Bolan Passes and had natural affinities with the steppes of Central Asia, Moslem invaders were greatly attracted to it and used it as a base for penetration into India. Even after the Moslems were established in India, this remained the way for armies, traders and travellers from Central and Western Asia and from Europe. In time a string of towns, greatly influenced by Islamic culture, grew up at commanding strategic positions on river crossings or central positions on the *doabs* (Map 1). In the 16th century, Sher Shah Suri, Emperor of India, developed the highway from the Khyber Pass to Calcutta. It then became a great business and commercial thoroughfare, and urban growth was accelerated. Admittedly, fairly large urban centres existed in the area before the Moslems came into power, but dominance of the Moslem culture and latter the British have obscured the indigenous pattern.

The Old City complex that we find in most cities of the area show somewhat similar morpohological features. Common historical and cultural associations, combined with the tendency to settle at water sites in this semi-arid plain, gave rise to large agglomerations having common characteristics.[1] These cities were the seats of Moslem power and administration and thus became remarkably similar in function and form. In almost all cases, they were fortified administrative and political centres and quite often Royal capitals.[2] Later, as commerce and trade developed, the cities grew and emerged as great centres of administration, culture, commerce and trade.

The British impact on the cities' growth and functions has been most striking. The English were a naval power; so they entered India during the 18th century from its seafront.

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1. N. S. Ginsburing. *Pattern of Asia.* (Englewood Cliffs : Prentice Hall, 1958), p. 545.
2. R. I. Crane, "Urbsanism in India" *American Journal of Sociology*, Vol. 66 (1954), pp. 469.

The ports of Calcutta and Bombay were two early areas of British influence. As a matter of fact, the very existence of metropolitan ports like Calcutta, Bombay, Madras and Karachi may be attributed to British planning and development. However, the British soon realized that effective control over India first necessitated control of the Delhi-Peshawar axis, the stronghold of the Moghul Empire. Their capital, which was first Calcutta, was changed to Delhi, the Moghal capital and the heart of the Empire. This political change reflected clearly the great strategic significance of the Upper Indo-Gangetic plain.

BASIC ELEMENTS OF CITY COMPLEX

Having studied the function, nature and morphology of 19 cities, all over 200,000 in population, of which Delhi and Lahore have over a million, is has been possible to generalize certain elements of settlement which are largely specific to the cities under study.

The Need for Protection

As pointed out earlier, the Upper Indo-Gangetic plain has been the highway of armies that came to rule India. The frequent wars and invasions created a need for protection from marauding raids. Therefore, the cities were often sited on a river bank or located on a highway. Since water and roads were the major avenues of transportation, such a site not only provided better defense and security, but also better opportunities for economic and cultural growth. Out of the 19 cities of 2,00,000 population in this region, 11 are located on river banks (Map 1).

Walled City

Almost all towns indicated on the map are enclosed by a wall, once again reflecting security considerations. A little distance from the wall was the moat, which in most cases is now filled in and is occupied by gardens around the city. The wall is usually of brick and is studded with gates, from four to 17 in number. Through these gates the roads lead to the core of the city where in the past they met in a square often the site of a mosque or temple. On both sides of the roads are shops and stores which constitute the major bazaars or business centres. The already narrow roads are made narrower by the encroachment of open shop fronts and booths on both sides. The bazaars are occupied by special classes of tradesmen and guilds of craftsmen.

Enclosed by the wall, the old city appears to be radio-centric in shape and to have regularity. However, the internal pattern of the city is irregular with a maze of criscrossing streets and alleys. Within a walled enclosure, often over-looking a river is the royal fort or palace. The royal fort at one time included residences of the king and the high government officials. Outside the fort there is generally a mosque where the king would say prayers with the city dwellers on important occasions. At other times certain festivals were celebrated within the palace and elaborate bazaars were held inside or just outside the palace walls. Therefore, the fort and the royal mosque, although most often on the fringes of the city, acted as a focal point.

Old buildings in the walled city are generally of red brick, wheras the newer houses are plastered with cement of pastel colors. The style and shape vary according to the tradition and culture of the people. Generally, houses are three to four stories high with shops always on the ground floor. The upper stories are often used by the house owner as his dwelling, and, if the family increases, an additional room may be added at the top. The houses are tightly joined, occasionally separated by a very narrow street measuring hardly three to four feet.

Lack of Functional Differentiation

Most cities in India and Pakistan, particularly those which are very old cultural centres, do not have separate residential and business centres. The walled cities are characterized by business cum residential structures along the streets. Well-to-do merchants and traders still live over their shops and offices, and a large proportion of day-to-day consumer needs are still met by artisans living or working in tiny shops at street corners or in the bazaar area.[1] Except for the Europeanized section in the Civil Lines, the city structures serve the purposes of both residence and business.

Community Quarters

As against lack of functional differentation, the cities of the Upper Indo-Gangetic plain indicate a strong tendency to differentation and discrimination between different groups of people. Although only a modified version of the Hindu caste system, there still remains a strong tendency for members of each religious community, caste, race or even occupational group to live together in one quarter.[2] Thus the city is divided into separate communities based on ethnic, religious occupational consideration.

ALIEN TOWN

With the coming of the English, the urban landscape of the whole sub-continent underwent a striking morphological change, and in the old cities, where past and present are living together, these changes are of great interest and complexity. Juxtaposition of the overcrowded and irregular old city of trades and handicrafts and the more spacious and often well-planned European center of administration, business and industry has been a feature of the city structure for over a century but is still alien to it. In the following, some of the

1. O. H. K. Spate, *India and Pakistan* (London : Methuen and Co., Ltd., 1954), p. 183.

2. H. F. Hirt. "Aligarh, U. P. : A Geography of Urdban Growth" (Unpublished Ph.D. dissertation submitted to the Dept. of Geography, Syracuse University, 1955), p. 80.

European elements are explained to show the contrast in settlement pattern between the indigenous town and the western city that surrounds it.

Cantonments

Among other elements of English origin, cantonments early formed the most conspicuous element added to the Indian scene.[1] In the words of Spate, the cantonments were a "monotonously planned open-developed town of European-style bungalows in large gardens along straight, broad roads, aloof and boring in a high degree, and absolutely dead in the heat of the day."[2] Besides the houses, bungalows and offices, the contonment complex included barracks for troops, a parade ground and a cluster of shops called the "military bazaar." This rectangularly-designed settlement constituted an important European stronghold when the English first arrived and was generally located well outside the limits of the old city.

Civil Lines

However, as the contact and influence of the English improved, they started to extend their control towards the central city. In time, a new colony emerged between the cantonment and the old city, the civil lines. This feature, completely foreign to the indigenous culture, was originally intended to be the new seat of civil administration. Therefore, the "Mall" of the civil lines became the site of public buildings, offices, banks, business firms, European-styled shops and stores. Occasionally, there appeared a cafe or bar, frequented by the Indian aristocracy and Europeans. Also in the çivil lines, around the business center, were the official residences or *kothees* of the English officials and the local bureacracy and lawyers. Civil lines has broad roads lined on both sides with trees and interspersed with gardens, play-grounds and western-style bungalows adapted to the dry, hot climate of the northwestern sub-continent.

Railway Colonies

Most cities in the Upper Indo-Gangetic plain were connected by the railway after the Great Mutiny of India in 1857. The network of railroads that developed had a striking influence on the urban landscape of the region. Since these cities were not only cultural and administrative but also military centers, the cantonment was directly connected with the cantonments in other strategic cities in the area.[3] But in time, as traffic and business grew, a larger staff was employed from the cities to run the railways more effectively. Since under the government plan the railway officials and employees were provided residence in the vicinity of the railway station, there evolved a new community,called the railway colony. Within such a colony one finds railway workshops, railway yards, and residence for railway employees.

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1. J. E. Spencer, *Asia, East by South* (New York : John Wiley and Sons, Inc., 1954), p. 141.
2. Spate, *India and Pakistan*, p. 183.
3. See the article, O. H. K. Spate and Enayat Ahmad, "Five Cities of the Gangetic Plain',, *Geographical Review*, Vol. XL, No. 2 (1950), pp. 260—278.

THE CITY OF LAHORE AS A CASE STUDY

Lahore, the old provincial administrative capital, owes its importance to its strategic site. Lying on the highway leading from Central Asia, it has been one of the poles of the vital Peshawar-Delhi axis. On the one hand was the Moslem northwest, with its strong climatic and cultural ties with the Middle East; on the other, the Ganges plain with Hindu influence. Up until 1013 A. D. Lahore, then called Panchalnagar, was in the hands of a Brahman king of Kabul, from whom it was wrested by Mahmud of Ghazni.[1] Since then Lahore has been a stronghold of Moslem power and a seat of administration and culture. In 1849, Lahore passed to the English, thereby ending a thousand years of Moslem influence.

Under the English, Lahore became an important trading and commercial center. The development of transport, industry and irrigation added to its significance. Lahore's strategic value combined with its nodality contributed then, as always, to its economic and urban growth.

Lahore, with a population of over a million, is today the capital of West Pakistan and the third largest inland city in the Indo-Pakistan sub-continent. Situated on the banks of the Ravi it is also at the junction of railway and roads from Karachi, Peshawar and Calcutta. The river flowing west once washed the walls of the city, but has now shifted its course and passes about one mile west of the city (Map 2). The strategic site on the river bank indicates the early need for security against frequent invations from the northwest.

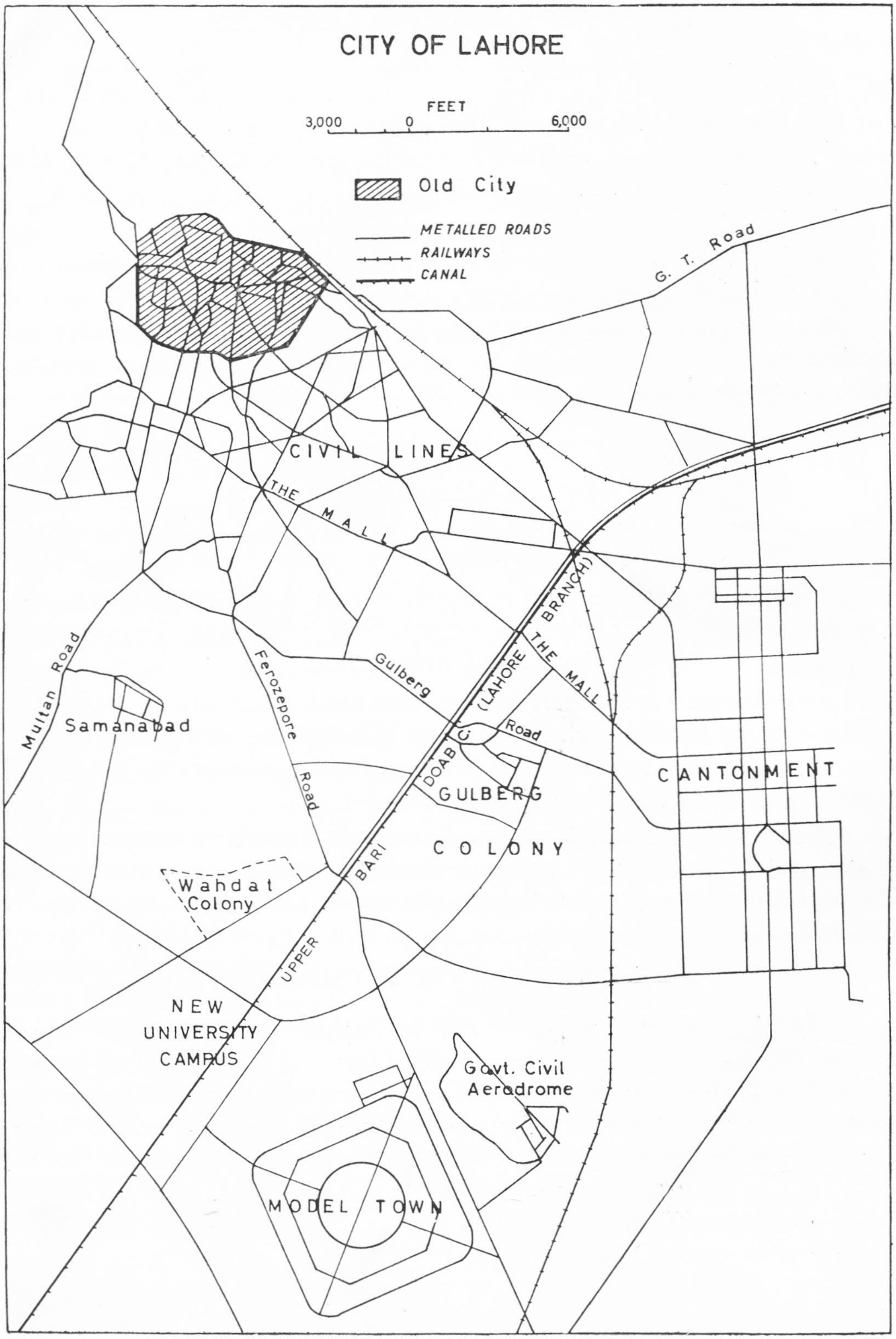
INTERNAL STRUCTURE

Looking at the map of Lahore, one can easily classify the city into two distinct categories, the old city and the new city. The old city is the core area and presents indigenous elements of both Hindu and Islamic culture. The new city is the creation of English and post English periods during which distinct features have been added to the city complex. Although juxtaposed together, these two sections may properly be called two cities, different in their character and functions. The old part offers the glory and culture of Medeival India, whereas the settlement in the new section reflect the occidental type of administration, business and industry.

ELEMENTS OF OLD CITY COMPLEX

Although Lahore was an important administrative center under the Hindus as early as the first century A. D.,[2] lack of historical evidence prevents a verification of urban conditions prevailing at that time. The fragmentary records of Lahore by Hiun Tsang, a Chinese pilgrim traveller who visited India in 646 A.D., gives some idea of the internal structure of the city.[3] He mentions that it was a large, Brahmanical city and that it was enclosed by a wall

1. *Im·erial Gazetteer of India.* Vol. 16 (London : Clarendon Press), p. 107.
2. *Imperial Gazetteer*, V. 16, p. 106.
3. *Imperial Gazetteer*, V. 16, p. 106.


CITY OF LAHORE
FEET
3,000
0
6,000
Old City
METALLED ROADS
RAILWAYS
CANAL
G. T. Road
CIVIL LINES
THE MALL
Multan Road
Samanabad
Ferozepore Road
Gulberg Road
(LAHORE BRANCH)
THE MALL
CANTONMENT
UPPER BARI DOAB C.
GULBERG
COLONY
Wahdat Colony
NEW UNIVERSITY CAMPUS
Govt. Civil Aerodrome
MODEL TOWN

Map. 2

with large inner gates. The streets and lanes were tortuous and winding, and the city was divided into quarters based on social and racial stratification in the Hindu caste system. The menial class workers have their dwellings outside the city walls'[1]

The period of Moslem rule was the golden time in the history of Lahore, and it was during this period that Lahore took its present shape. Under the Moghals it became a place of royal residence and grew to be a resort for people of all nations. Akbar, Emperor of India, held his court at Lahore from 1584 to 1598.[2] He enlarged and repaired the old fort and surrounded the city with a wall, portions of which still enclose the old city. The core city covers an area of about one square mile. The brick wall around it is about 30 feet high and once was strengthened by a moat and other defences. Now, however, the moat has been filled in and is a garden around the city. A metalled road ran around the city which had access from 13 gates. The citadel or fort rose upon a slight but commanding imminence at the northeastern angle and abutted northward on the old river bed.

Within the city are narrow and tortuous streets, some of them dead-end, lined on both sides by four to five-story buildings. The street pattern, though completely irregular and unsystematic, has advantages of security and weather. The winding roads provide an easy means of defense, and the narrow streets keep the hot summer sun from hitting the ground. In many interior communities a gate fixed at the exit of the dead-end road provides a citadel within a citadel. In the fort, the magnificent buildings of the Mughal period are in contrast to the simple dwellings in the city. The city wall has 13 gates, and a road reaches the center of the city from each of these gates, ending in a fairly open square where the biggest reservoir (*talab*) in the walled city is located. In the past the reservoir stored water for emergencies. The thirteen streets constitute the business arteries of the old city and are called bazaars. Other feeding lanes, from four to eight feet wide, join them from various directions, depending upon the consideration of distance rather than plan.

The royal mosque outside the fort brings most of the Moslem community together on religious festivals, when huge congregations form. The mosques in the walled city often constitute a focal point of a ward or a community. There are also innumerable temples and gurdwaras, which before Partition provided religious services for the Hindu and Sikh communities. The mosque or temple is usually located in a central position often at the crossings of streets. Every quarter or community has its own coffee house, *hamam* (public bath), sweet shops, religious school and other sources of everyday needs. Thus, within the walled city we have various religious, racial, and occupational groups, living together but still confined for the most part to their own group or clan. There are two markets in the old city, one for vegetables and the other for meat, which meet the local needs and are an avenue of social intercourse between various groups.

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1. Hirt, *Aligarh*, p, 80.

2. *Handbook for Travellers in India, Pakistan, Burma, and Ceylon* (London : John Murray, Publissher, 1953), p. 340.

NEW CITY ELEMENTS

Looking at the map of Lahore, one finds that areal spread of the city took place primarily during the British rule. The walled city, with its indigenous characteristics, was not suitable for the English requirements. The cultural differences and industrial technology that the English had set them apart from the indigenous culture. Thus, their earlier buildings were raised outside the old city for the purpose of isolation and security from the local population. Later on, as security increased and the city grew, the old and new sections merged to form one compact settlement of both indigenous and foreign elements.

Cantonment

The cantonment was the first English element. It was built around the beginning of the 19th century and lies five miles to the southeast of the city.[1] The original purpose of the settlement was military in nature and thus it mainly included barracks for the troops. Now it has become a high income residential area for both Pakistanis and the English. However, the bungalows and barracks are still occupied by army officers and military troops.

The cantonment is separated from the civil lines by a railway, obviously for purposes of security and transport. The roads are perfectly rectangular and are quite distinct from the irregular and unsystematic pattern in the old city. There is a polo ground and a parade stadium, where important military sports are held. A shopping center, the Military Bazaar, serves the needs of the officers and troops residing in the cantonment area.

Civil Lines

Under the English, Civil Lines served as the seat of district administration. In the middle of the Civil lines runs the Mall, on both sides of which are the western-style business district. The road pattern in the civil lines, though systematic, does not follow the grid system employed in other Europeanized sections, but the roads are open and lined with trees. The gable-roofed dwellings (*kothees*) of the cantonment are replaced by houses and buildings of indigenous styles. In the case of important public buildings such as the High Court House, the Lower Court, Government House, Gymkhana Club, Assembly Hall and the General Post Office, the architecture is a good blend of the Islamic , Hindu and European cultures. Despite all this blending, the cafes, banks, European firms, cinemas, race course and large open gardens still give it a foreign air, if not quite British. The shops on both sides of the Mall deal in business of various sorts, ranging from cars to needles. The buildings are generally of brick and are not generally more than three stories high. The upper stories are used as office space or as apartments for middle and upper-class people. The general skyline of "downtown" is flat, occasionally broken by a tall public building or a church spire. Schools are generally conducted by missionaries, but local children constitute most of the student body. Away from the Mall, one gets into the upper-class residential area with the bungalows occupied by foreigners, Pakistani Officers, landlords, and other richmen.

The civil line has been extended in all directions, thereby merging with the walled city, on one side, and the cantonment on the other. Between the Mall and the Circular Road that

1. *Handbook for Travellers* ...., p. 358.

runs around the walled city is the transition between the old and the new. The shops and residences are of a lower order and prestige than those on the Mall, but certainly higher than in the walled city. Between civil lines and the cantonment the land is mostly occupied by upper-class residential bungalows. The land along the canal between the cantonment and Gulberg is one of the choicest residental areas today.

Railway Colony

The coming of the railway to Lahore had great influence on its settlements. Since Lahore was strategically located and acted as a hub of transport between Peshawar, Karachi, Delhi, and Calcutta, it became a railway junction. The government constructed a railway workshop and yards to provide the necessary services for the railway department. Lahore station is today the largest railway junction in Pakistan.

Due to its significance as a railway center, Lahore acquired another element alien to its indigenous characteristics. Along the railway line to the east, there evolved a railway colony, which is occupied by railway officials of every rank. Immediately next to the railway line are extended rows of one-story dwellings which provide residential facilities to the railway employees. Mayo Gardens in the southeastern part of the city constitutes residences for the upper-class railway employees These dwellings are laid out in rectangular pattern and are thickly interspersed with trees. The houses are one-story and quite spacious, and are surrounded by extensive lawns with trees and hedges surrounding the garden. The place was obviously meant for English officers to save them from the hot summers of Lahore. The whole section of railway quarters and Mayo Gardens is only 60 years old and is reminiscent of English culture.

Industrial Sector

Lahore is one of the leading industrial cities of Pakistan. The textile industry goes back to Moghal days, when Lahore as the Imperial capital had a large market dependent on the court. The leather industry is also an old industry, which once met the local demands of the Moghal court. Under the English these industries declined in competition with new industrial factories in other parts of the country. However, craft production has remained important as gold and silver jewellery, lace, carpets and rugs are important elements of the indigenous culture.

Since industrial, commercial and residential functions in Lahore have been intermingled, there is no section or area which may be termed as industrial in nature. A great deal of merchandise is still produced by artisans in their own homes. A few modern factories that have been built are lying on the outskirts of the city, particularly to the north of the Ravi River, and might be classified as an industrial sector.

POST INDEPENDENCE ELEMENTS

The feature that first strikes an observer in Lahore is the planned growth of the city since Partition. Government and civic planning has become an important feature of the new settlements developed during the last eighteen years. The keenness and particularity with which the new sectors of the city are being planned and developed has set a new trend in the growth of cities in Indo-Pakistan.

Walled City Development

Morphological change in Lahore after Partition has taken place along two lines. One is to rehabilitate and rebuild those parts of the walled city which were destroyed during the communal riots before Partition. Second is the development of new residential areas or colonies to reduce the congestion from the already overpopulated city. Planning and reconstruction some of the damaged parts of the city have thrust new settlement features into the heart of the old city. Wide roads lined with trees and shops arranged in a regular order are quite a change from the old pattern in which they now are set. Shah Alam Bazaar is a good illustration of the changing order in the old city structure of Lahore.

Suburbanization

Civic planning has been more active in extending new residential areas into the outskirts of the city. Cultural borrowing from the west is clearly expressed in the pattern and functions of these residential areas. The two new residential sections are laid out along the southwestern and southeastern peripheries of the city. Gulberg Colony (Map 2) in the *southeast*, covers about three sqaure miles and is an upper-class residential area with bungalows of the local elite, firm representatives and diplomatic officers from abroad. The pattern is rectangular, and the streets are wide and lined with trees. It has schools, playgrounds, a stadium and a shopping center, indicating a marked similarity in design and nature with American suburbs. Samnabad Colony, covering abcut two square miles, is a middle-class residential area. This government project is designed to accommodate middle income group people moving out from the walled city.

CONCLUSIONS

Summarizing the paper, it may be concluded that urban occupance in the Upper Indo-Gangetic plain has been strongly influenced by its history. Concentration of large urban centers in this region may be attributed to the geographic location that helped established ancient seats of culture, administration and trade. Settlement elements that constitute the total city structure are the result of a long period of evolution, to which various cultures and creeds contributed. The present pattern, size and character of the cities are the product of the successive Hindu, Moslem and English cultures that have penetrated into this region.

The study of 19 cities, in terms of their morphological characteristics, indicates that the common cultural heritage of the Upper Indo-Gangetic plain has imparted to them a remarkably similar form and function. In all cases, the city structure is made of an old city and a new city, the former an unsystematically laid out walled city and the latter a well-planned occidental community. The cultural elements, as exemplified by study of the city of Lahore, show the arrangement and setting of a typical city in the Upper Indo-Gangetic plain. The post Partition growth of Lahore indicates the increasing role of government planning in the newly developed settlements. The rectangular street pattern, boulevards and divided highways that are emerging on the scene are adding new elements to the mosaic of the city of Lahore.

The Twentieth International Geographical Congress was held in London under the auspices of the Royal Society from 20th to 28th July, 1964 at the Imperial College of Science. Professor Carl Troll of the University of Bonn Federal Republic of Germany was the President. It was inaugurated by Her Majesty the Queen. About 1500 delegates from different parts of the world attended the Congress. Dr.KaziS. Ahmad, Professorof Geography, University of the Punjab, Lahore, Dr. Nafis Ahmad, Professor of Geography, University of Dacca and Dr. Mushtaqur Rahman of the University of Karachi, Karachi represented Pakistan.

The Congress was divided into nine sections and seventeen Commissions to which more than 3000 papers were contributed. Dr. Kazi S. Ahmad contributed a paper on "Some Geographical Aspects of the Indus Waters Treaty and development of irrigation in West Pakistan". and Dr. Mushtaq-ur-Rahman on "Rural Settlements in Sind".

Local excursions in and around London were arranged. A number of exhibitions of maps including that of National Atlases were held.

British National Committee for Geography under the Chairman-ship of Prof. L. Dudley Stamp, C. B. E made excellent arrangments for the stay of the delegates and every effort was made to make them comfortable. Delegates were entertained at a number of receptions practically every day.

On the occasion of XXth Geographical Congress in recognition "of their distinguished services to the International Advancement of Geography the Council of the Royal Geographical Society elected the following persons into Honorary Corresponding Membership, which also carries with it the privileges of Fellowship :

1. Professor Carl Troll, University of Bonn, German Federal Republic, President, International Geographical Union, 1960—64.
2. Academician I. P. Gerasimov, Academy of Sciences, USSR Moscow, President elect 1964—: Vice President, I. G. U. 1960-64.
3. Professor Chauncy D. Harris, University of Chicago, U.S.A. Vice-President I.G.U. 1956—60; 1960—64.
4. Professor Hans H. Boesch, University of Zurich, Switzerland, Vice-President, I.G.U. 1956—60; Secretary-Treasurer 1960—64 1964—.
5. Professor Hassan Awad, University of Rabat, Morocco (formerly University of Cairo) Vice-President I. G. U. 1956—60; 1960—64.
6. Professor George Kuriyan, formerly University of Madras, India, Vice-President I. G. U. 1952—56; 1956—60.
7. Professor Kazi S. Ahmad, University of Lahore (Pakistan).
8. Professor Funio Tada, University of Tokyo (Japan), Vice-Presidnt I. G. U. 1956—60; 1960—64; Chairman Japan Regional Congress I. G. U. 1957.
9. Professor Hilgard O' Reilly Sternberg University of California (U. S. A.) Vice-President I. G. U. 1952—56; 1956—60; Organizing Secretary Rio Congress 1956.
10. Professor Georges Chabot, Director of the Institute of Geography, Paris.
11. Professor Kenneth B. Cumberland, University of Auckland, New Zealand. Vice-President, I. G. U. 1960—64.

The Diplomas of the Membership were awarded by Royal Highness Princess Merina, the Duchess of Kent at an exclusive ceremony during the reception of the Royal Geographical Society to the delegates on the 23rd July, 1964.

The Congress was preceded and followed by Symposia on various aspects of Geography and field studies in different parts of the United Kingdom. Dr. Kazi S. Ahmad was invited to preside over one of the a sessions of the Symposium on "Urban Geography" held at Edinburgh from 30 July to 6th August. He also contributed to it a paper on Urbanization Trends in West Pakistan". Meetings of the International Cartographic Association which is affiliated to the International Geographical Congress were also held at Edinburgh along with the Symposium.

The Royal Scottish Geographical Society Edinburgh at a reception held on 1st August 1964 conferred Medals and Honorary Fellowships on the following persons for their contribution to the knowledge of Geography and work respective fields :

(A) Medals :

(1) The Scottish Geographical Medal (Gold Medal) to Professor L. Dudley Stamp, London, President of the Royal Geographical Society, and Chairman of the XXth I. G. Congress, London.

(2) The Livingstone Medal (Gold Medal—to Professor Eduard Imhof, Zuirch, first President of the International Cartographic Association.

(3) The Research Medal to Professor Arthur E. Smailes, Queen Marry College, London, for original work on Urban Geography.

(B) Fellowship :

(1) Professor Kazi S. Ahmad, University of the Punjab, Lahore, Pakistan.

(2) ProfessorA.N. Baranov, Chiefofthe Directorate of Geodesy and Cartography of the U. S. S. R.

(3) Professor Hans H. Boesch, University of Zurich, Switzerland.

(4) David P. Bickmore, Oxford, Editor of the "Atlas of Britain and Northern Ireland".

(5) Stephane De Brommer, Institut Geographique National, Paris, France.

(6) Professor Henri Gaussen, Paris, Director Vegetation Survey of France.

(7) Professor I.P.Gerasimov, USSR Chairman, National Committee of Soviet Geographers.

(8) Professor Erwin Gigas, Institute fuer Angewandte Geodaesie, Frankfurt am Main.

(9) Charles B. Hitchcock, Director, American Geographical Society.

(10) Professor S. Kiuchi, University of Tokyo.

(11) Professor Aymond E. Murphy, University of Hawaii, Honolulu.

(12) Professor Konstantin A. Salischev (Cartography) Moscow.

(13) Professor Carl Troll, University, Bonn, President of the I. G. U. 1960—64.

The Diplomas were awarded by Lord Cameron, the President of the Society.

At the last meeting of the General Assembly elections were held to various commissions. Dr. Nafis Ahmad was elected to the Commission on the Teaching of Geography. It was decided to hold XXI Geographical Congress in December, 1968 in India and Dr. S.P. Chatterji of the University of Calcutta was elected as the President.

THE BRITISH ISLES : A SYSTEMATIC GEOGRAPHY : By J. Wreford Waston and J. B. Sissons—editors, 452 pp. Nelson (London) 1964 45 shillings.

Twenty three British Geographers have contributed to "The Britsih Isles : A Systematic Geography" which is an official publication of The International Geographical Union, to mark the 20th Congress, which was held in London in July 1964.

Though the publication of this book has rapidly followed the publication in 1962 of "Great Britain : Geographical Essays"—edited by Jean Mitchell, it by no means duplicates it. The books need to be used in conjunction with each other if a full picture of the geography of Great Britain is to be obtained.

The first chapter deals with "The Individuality of Britain and The British Isles", and though each succeeding chapter is written by a difierent geographer it is this aspect of Britain which is often emphasised, giving the book a unity which is often absent from collections of essays.

The physical basis of British geography receives very adequate attention and sets the stage for the development of the economy under the hand of Man. Separate chapters are devoted to Prehistoric Geography; Historical Geography, (from the coming of the Anglo Saxons to the Industrial Revolution); and The Industrial Revolution. Students of the Geography of the British Isles will realise that this is essential if the present day economy is to be understood.

The last ten chapters are chiefly devoted to the economy of the British Isles and recent trends and changes in the patterns of agriculture, industry, transportation and population are emphasised. The final chapter by Prof. W. G. East on "The British Isles in Their World Context" is a fitting end to this scholarly though very readable book, as it traces the role of Britain through the centuries from the Megalithic Period to the recent negotiations to join the European Common Market.

This book is to be highly recommended to the thoughtful georgapher, since it is not just concerned with the presentation of facts, but reveals the many problems which face the British people, to which the geographer together with other specialists is attempting to find the answers.

MARY P. COOPER.

BOOK REVIEWS

A SHORT HISTORY OF GEOGRAPHICAL DISCOVERY. By A. Torayah Sharaf XV and 417 pp.; Bibliogr., Indexes. M. Zaki el Mahdy, Alexandria. 1963. $7\frac{1}{2} \times 5\frac{1}{2}$ Inches.

History of exploration and discovery is a subject of great importance to geographers in that it familiarizes them with the development of geographic thoight. Although there is evident need for more and more interest in this important field of geography, it is surprising that the existing notable works are not only too few but are also fairly out of date. This book by Sharaf is a step forward in the direction of partially fulfilling these gaps. In general, the book is organized with an objective to familiarize the reader with the development of geographical discovery both in practice and theory, from the earliest recorded times to the contemporary period.

Judging in terms of its contents, the book may not seem to present anything new from what has already been discussed in the existing literature on the subject. However, on closer examination of the subject matter discussed in this volume it will become evident that it is unique in at least two respects. Firstly, this book is significant in that it lays more emphasis on Muslim period with a view to pointing out the advancement made by the Muslims in exploration and geographic thought. Chapters V and VI, which deal in Muslim geography, are a valuable contribution to the field in that the English or other European literature has woefully inadequate information on the subject.

Secondly, the exploration of Africa discussed in Chapter XVI is another feature of distinction in the book. The author in this chapter attempts to point out that the African continent, termed as the dark continent by the Europeans, is now emerging as a focus of great nations. Since Africa is becoming a center of attraction to outside observors, particularly Asians, the emphasis laid on the continent's ancient civilization and its bearing on the geographic exploration and thought will give a clearer understanding to non-African readers. Considered from these two aspects it may be suggested that the book makes a vauable and up to date addition to the existing literature on the history of exploration and geographic thought.

R. A. MALIK

PAKISTAN GEOGRAPHICAL REVIEW was instituted in 1949 replacing Punjab Geographical Review which was started in 1942. The object of this publication is to further dissemination and exchange of scholarly knowlege. Its volumes contain research articles on various topical and regional themes of Geography with particular reference to Pakistan. The Review is published half-yearly in January and July.

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