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TO CONTRIBUTORS.

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2. The contributions are classified into the following categories:—

(1) **Papers** which contain the results of an original investigation. Reviews of current research on a particular subject are also treated under this heading. They should not normally exceed 15,000 words in length.

(*See inside of the back cover*)

SOME ASPECTS OF WATER CONTROL IN WEST PAKISTAN

BY

H. VLUGTER

Adviser to the Government of Pakistan

In an agrarian country like Pakistan with pressing problems of food production the water will, undoubtedly, have to be considered one of the most important natural resources.

A careful exploitation and conservation of the water therefore is a necessity of vital importance for the population and there should be taken measures by means of which the fertility of the soil will be preserved and the highest possible productivity achieved.

Up to now water-control in West Pakistan has been limited to irrigation works, bunds (dikes) along the rivers here and there, some open drains and a number of tubewells.

One may have the greatest admiration for the harnessing of the mighty Indus and its tributaries by spectacular barrages and for the large irrigation canals having secured the irrigation of so many millions acres of land, but at the same time one realises that this is only a part of what the control should be.

We all know by now that in summer time the rivers or the heavy downpours are inundating the fields that severe waterlogging exists, caused by the rise of the ground water table to the surface and that salinity occurs on so many acres of fertile land.

It is the duty of the water controlling services not only to prevent all this but also to reclaim the already deteriorated soils.

Flood control can be done by making high and strong dikes along the rivers or by constructing big reservoirs in the headwaters.

Waterlogging can be cured by an open drainage system or by tubewells and salinity by supplying such a quantity of irrigation water that a downward water-movement in the soil leaches down the salt to the substrata.

Now I should like to discuss about waterlogging and salinity and only from a mere technical point of view and so leaving the economical parts of the problem to the agronomists and the solution of the social difficulties to the people of Pakistan and their Government.

Waterlogging in West Pakistan is caused both by rainfall and irrigation water, part of which infiltrates into the soil, thus causing a continuous raising of the ground water table.

One cannot and must not prevent this phenomena. Even under the most favourable conditions of cultivation and careful irrigation not all the water will evaporate or will be taken up by the roots of the plants and this is as well for we need a slow downward water-transport in the soil to hold down the salt.

In West Pakistan unfortunately the fields are as a rule not the whole year round under cultivation and irrigation water often is not used economically. Moreover there is a lack of storm-drains as a result of which the percolation is higher than it could be and amounts, depending on the permeability of the soil from 5 to 20% of the rainfall and irrigation supply, causing a rather rapid raising of the ground-water. A rise of 1 foot per year is observed in the Punjab and especially in the Northern Thal area during the years after the Jinnah Barrage was completed the ground-water on an average has even risen by 3 feet a year. "As the ground-water-table 50 years ago was 50 to 70 feet below the natural surface now in the irrigated areas it has come very near to the surface, as a result of which waterlogging can be observed all through Western Pakistan. Large regions of former green lands now give the impression of being snow-landscapes. Village dwellings, once built in the desert, now float on lakes and roads are damaged and bumpy. But how can we solve the problems technically? Surely tubewells may be a solution. By pumping up the water that has been infiltrating the soil we can lower the ground water table and by giving the tubewells a sufficient capacity bring it to a desired level. This in combination with a storm-water drainage system will undoubtedly improve the situation, especially when the ground water is not saline. The question about the economics of such a scheme will have to be answered by the agronomists.

A second solution to the watelogging problem is a complete drainage system with open storm-water and seepage drains as main drainage scheme while having in connection with this farm or field drains on every acre. This system has to cope with the run-off and that part of precipitation and irrigation water which percolates through the soil to maintain a ground watertable of about 3 to 4 feet below the natural surface.

In the Netherlands, where from the drains in the so called polders the rain and seepage water is pumped up, the suitable water table for plant growing is considered to be in clay soil, 3 to 3·5 feet for arable and for grass-land 2 to 2.5 feet where as in sandy soil 3 to 3.5 feet arable and 1.5 to 2 feet for pasture. And with these water tables the highest yields of Europe are obtained.

Of the two above mentioned systems the first we may call the American system, the second the Dutch one.

However, in Pakistan the solution should be adjusted to the circumstances prevailing here. Climatic conditions as well as economics, the silting up of the canals as well as the farmer's habits, the abundant vegetation in the drains as well as the maintenance of machineries all have to be taken into account.

Throughout many past years a marvellous irrigation system has been created and well maintained, during few future years there shall have to be a drainage system established all over the irrigated areas in West Pakistan, and kept as well, or the process of going out of production of hundreds of thousands of acres will be going on, and going on progressively.

Although nature has provided the land with big rivers it has left the ground in between two rivers, the doabs without a natural run-off system. So this we have to make ourselves. I often heard that the slope of this country is so much flat that the maintenance will be too expensive. I have my doubts, knowing that in the irrigation channels with slopes of 1 to 5,000 to 1 to 10,000 heavy silt-laden water is flowing without causing much trouble. As a good farmer will take care not to lose his valuable top soil, erosion will be prevented and the outfall in the drains must be clear water. So in a good drainage system the slope may be flatter than needed for irrigation channels. But then how to prevent slushing of the banks, how about weed-growing in the drains. To my opinion the answer to many questions is a combined irrigation-drainage system, instead of irrigation channels on the ridges and a separate draining system in the depressions. By letting the designed main drains convey irrigation water that can be used on the fields more down-streams the advantages are manifold.

1. With this system the total needed capacity will be less than by separating irrigation and drainage canals.
2. The drain-water is used for irrigation so there will be no losses any more.
3. It is not necessary to line the channels because the seepage water flows through nearby drains and is used again.
4. The maintenance cost will be low because there is always running water in the drains.
5. Being a gravity system it is more suitable to this country.

Needless to say there are many modifications and possibilities around this idea which cannot be discussed right here but I am convinced that the combined irrigation and drainage system would work out well under the meteorological, hydrological, agricultural, economical and social circumstances existing in this country.

Once having fixed the water table at 3 to 4 feet below the surface there will be no stagnant water and no waterlogging. The evaporation from such a water table will be somewhat more than in the case of a 10 feet deep ground-water table but will not exceed one tenth of that of a free water surface.

To prevent salinity, rain plus irrigation water percolating through the soil must be more than the evapotranspiration. This equation enables us to calculate the maximum duty of the irrigation water.

It is most probable that there will not be sufficient irrigation water to conservate all the available land. In that case it is highly advisable to have under cultivation only the better soils, having perennial irrigation on those fields which permit intensive agriculture and not to spread the water over too big an area with extensive cultivation.

I do not under-estimate the almost insuperable social and financial difficulties arising. But I hope they will be a challenge to all concerned and united in the fight against nature.

From the experience of my own country I am aware that such a persistent struggle can result in strength and endeavour. In fact, in Pakistan this battle has already started and through quick action and the utmost efficiency it may, and I hope it will, end in victory.

SOIL EROSION BY THE INDUS AND ITS TRIBUTARIES

BY

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Sediment Content of a Stream, a Measure of Soil Erosion

Important agencies causing soil erosion are, the wind and the water. In the northern regions of West Pakistan, the latter is the main medium of transportation of soil and the disintegrated rocks. If the sediment carried by a stream draining a particular area is estimated, it can give a good conception of the total amount of soil eroded from that area.

Rivers in the hills usually flow through confined sections and carry away all the sediment load brought by them. All the important tributaries of the Indus, such as the Siran, the Harrow, the Soan, the Kabul and the Kurrum flow through hilly tracts and so does the tributaries of the Jhelum such as the Kishanganga, the Kunhar, the Poonch and the Kanshi. The Jhelum itself also passes through hilly tracts upto Domel. In fact Kalabagh is the first site on the Indus and Mangla on the Jhelum where the rivers debouch out of the hills into the plains. Sediment estimation in these streams within their hilly regions can give the type, nature and order of erosion.

Changes in Sediment Character in the plains.

In the plains many complications appear in the transportation of sediment load of a stream. Usually, in these regions canals are taken out for irrigation of the land. A certain percentage of the sediment load of the river is thus carried away by the canal to be deposited on the fields. Whenever a river passes a flood overspilling its banks, a certain percentage of its load is spread and retained on the land. A third factor is the persistent process of selection and rejection of bed materials which is continued right from the beginning of a stream to its end. Coarser grades are rejected and finer ones are picked up and brought in suspension. This process is more pronounced when a river opens out into the plains. These three causes make the estimation of soil erosion on the basis of sediment load of a stream, located in the plains, difficult.

In this note an attempt has been made to estimate soil erosion, its characteristics, quality and quantity on the basis of measurements carried out at various river sites during the years 1953 to 1958.

Soil Erosion in the Catchment of the Indus and its Tributaries.

The rivers studied in this note include the Indus at Durband and at Kalabagh, the Siran at Thapla, the Kabul at Warsak, the Swat at Munda, the Harrow at G.T. Road bridge, the Soan at Mukhad Road, the Kurrum at Kurrum Garhi and the Gomal at Gulkach. These sites of observation are shown in Fig. 1. Practically all of these are located in hilly regions. The data showing the mean of annual sediment load brought from the drainage area, total run off and other measurements are shown in Table I. This information includes, the annual sand, silt and clay contents carried in suspension and in motion at the bed of the river. The last part of the sediment load was not actually measured but was assumed equal to 20 percent of the total suspended load and was added to the sand content. The silt and clay contents are shown separately and added together. On the basis of total sediment in acre feet, total soil erosion in tons from one sq. mile of the catchment area and in terms of foot per sq. mile was also worked out and shown in the table.

Similar estimation of annual erosion from the catchment area of the Jhelum and its tributaries is given in Table 2, that of the Chenab, the Ravi, the Beas and the Sutlej is given in Table 3.

Discussion of the Results of Observation :

1. Soil Erosion in the catchment of the Indus and its Tributaries.

A study of table I brings out interesting conclusions. The soil erosion upstream of Durband is considerable, attaining an order of 2820 tons per sq.mile. This load contains sand equal to 54% of the total materials. The main catchment of the river consists of high ranges of mountains, some possessing perpetual snow and glaciers. Beside river erosion and part of the load is also contributed by morainic debris through glacial regelation. It seems that all the eroded material is carried down to Kalabagh where the order of erosion again remains equal to 2908 tons per sq. mile suggesting that very little deposition of sediment takes place between Durband and Kalabagh.

The drainage regions of the Kabul upto Warsak seem to be very similar to that of the Indus above Durband. It passes sediment equal to 1998 tons per sq. mile per year, a major portion of which is sand.

The eroded soil brought in by other streams joining the Indus represents a different picture. The Kurrum for instance, passes the highest order of eroded material amounting to 10272 tons per sq. mile, nearly $3\frac{1}{4}$ times that of the Indus above Durband. The sand constitutes only 29% of the total soil eroded in a year. It seems that the drainage area of the Kurrum consists of erodable soil with the least restraining cover. The eroded materials carried by the Soan, the Siran and the Harrow is similar to that of the Kurrum although the annual sediment transport is low. The water of the Swat carries the least amount of sediment content but its runoff from its catchment is considerable, so that the soil eroded in tons per sq. mile is rather high. A study of the character of the sediment carried by the Swat represents that it is also due to the disintegration of rocks.

The results of Gomal river are not discussed as its data are not sufficient.

The order of soil erosion from each catchment of the tributaries of the Indus is also depicted in Fig. 1.

2. Soil Erosion from the Catchment of the Jhelum and its tributaries:—

The soil eroded by the Jhelum and its tributaries is depicted in Table 2 which shows the details of the various constituents. A study of this table shows that all the tributaries of this river carry a considerable amount of eroded soils which range from 5868 to 3400 tons per sq. mile. The poonch carries a very high order of the erosion. Similar high order of sediment load at Mangla represents that a considerable erosion is taking place from the land below Muzaffarabad and upto this site.

Another important conclusion is that in this river system the amount of silt and clay representing erosion of soil is significant. More soil is being lost from the catchment area of the Jhelum. Addition from the disintegration of rocks is comparatively less. Kanshi river although draining a highly eroded area and passing a high percentage of sediment, to discharge yet does not carry large amount of soil erosion due to its low annual runoff.

The catchment of the Jhelum seems to be highly deteriorated and needs extensive soil conservation.

3. Soil Erosion from the Catchment of the Ravi, the Chenab, the Sutlej and the Beas.

It has not been possible to collect detailed information for the tributaries of Chenab, Ravi, Sutlej and Beas rivers as these lie in India. These rivers when enter Pakistan have already opened out in the plains, even the sites for observation selected are also not high up near the hills. The observations for the Chenab were conducted at Chiniot after major withdrawals had taken place in its upper regions.

The observations for the Ravi were conducted at Shahdara near Lahore draining a considerable flat land. The data for the Beas and the Sutlej has been collected from Indian sources. The full information for these four rivers is given in table 3.

The Chenab at Chiniot has passed sediment corresponding to 2550 tons per sq. mile. Before this site major withdrawals had taken place out of the river. If the sediment withdrawn by Lower Chenab, and Upper Chenab Canals and that spread on the land is taken into account by using the known percentages of sediment to discharge, the total sediment withdrawn comes to 25,000 A. Ft. which includes about 10,000 ft. A. Ft. of sediment left on the flood plains during major spill floods.

The detail of this estimation is given below :—

Canal	*Withdrawal in M.A. ft.*		*Sed. in A. ft. in withdrawal.*	
	Rabi	Kharif.	Rabi	Kharif.
Lower Chenab CANAL	2.916	3.854	2041.20	9245
Upper Chanbe CANAL	0.539	1.338	377.7	4195
Total	3.455	5.192	2518.9	12450

The sediment withdrawal was worked out by multiplying Rabi discharge by 0.07 and Kharif by 0.25. The total sediment spread on the land by irrigation waters being 14959 A. Ft.

Again in 1957 spill floods above 150,000 cusecs passed 1.632 million cusecs carrying 414220 A. Ft. of sediment and assuming 25% of this left on the flood plains, the total sediment deposited on the land amounts to 10,000 A Ft. Thus the total sediment redeposited comes to 25,000 A. Ft. If we add this amount to that actually measured at Chiniot, the total sediment at Akhnoor a site where the river comes out of the hills, amounts to 63,000 A. Ft. which corresponds to an erosion of 4228 tons per sq. mile Thus the catchment area of this river is also deteriorated and needs soil conservation measures beyond the boundaries of Pakistan.

As to the sediment transport of the Ravi as shown in Table 3, the data of the three summer months of 1958 give an order of erosion equal to 17145 tons per sq. mile. Such a high order of erosion points out to the highly deteriorated catchment of the river. The data of Beas and Sutlej rivers are not discussed in this note.

Soil Redeposited on the Land.

It was stated before that with the withdrawal and during spill floods some of the sediment load is redeposited on the land. A brief estimate of this factor was carried out for the Indus at Kalabagh, and Jhelum at Mangla. The Chenab as we have already shown redeposits a large amount of soil on the land. The comparative figurs of redeposition for the Chenab, the Jhelum and the Indus, are 25,000,7000 and 8000 A. Ft. per year respectively. The basis of these calculations are given in Special Report No. 188-Ph/Sed-37/60, issued by the Irrigation Research Institute.

Soil Erosion Order of Rivers

The soil erosion in the order of intensity from various catchments drained by different rivers is given below in the form of a table.

S.No.		Rivers	Catchment area. (Sq.mile)	Erosion in tons/sq. mile	Erosion in ft/sq. mile.
1.		Ravi	3123	17145	150×10^{-4}
2.		Kurrum (Indus)	2633	10272	$90. \times 10^{-4}$
3.	(i)	Poonch (Jhelum)	1520	5783	62×10^{-4}
	(ii)	Mangla (Jhelum)	13180	5868	52.8×10^{-4}
	(iii)	Kunhar (Jhelum)	1080	4560	41×10^{-4}
	(iv)	Domel (Jhelum)	5280	3371	32×10^{-4}
	(v)	Kishanganga (Jhelum)	2600	3516	31.6×10^{-4}
4.		Chenab	26078	(i) 2649	20×10^{-4}
				(ii) 4228	383×10^{-4}
5.	(i)	Indus (Kalabagh.)	1038300	2908	26.2×10^{-4}
	(ii)	Durband (Indus)	63600	2820	26×10^{-4}
	(iii)	Kabul (Indus)	26000	1998	18×10^{-4}
	(iv)	Soan (,,)	4800	1950.4	17.6×10^{-4}
	(v)	Siran (,,)	1100	1250	11.3×10^{-4}
	(vi)	Swat (,,)	4810	1058	9.5×10^{-4}
	(vii)	Haro (,,)	2400	916	8.3×10^{-4}

CONCLUSIONS.

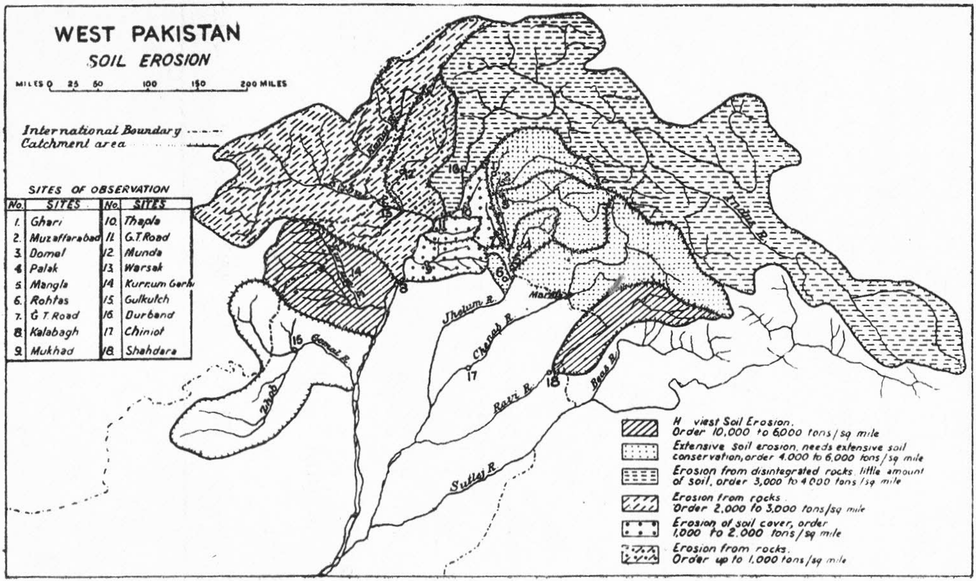
1. The soil being eroded by the Indus is not harmful to the country. Some of the soil, load is being redeposited on the land.

2. The Jhelum and its tributaries are passing a very high order of soil eroded and is resulting in a great loss of useful soil cover and needs extensive soil conservation measures.

3. The catchment area of the Ravi and the Kurrum are notorious for yielding the largest amount of soil being eroded annually.

4. Catchment of the Chenab is also equally deteriorated. The quantity of soil erosion from the catchment of this river is, however, comparatively less than that of the Jhelum.

FIG. No. I



WEST PAKISTAN
SOIL EROSION
MILES 0 25 50 100 150 200 MILES
International Boundary
Catchment area
SITES OF OBSERVATION
No. SITES No. SITES
1. Ghari 10. Thapla
2. Muzaffarabad 11. G.T. Road
3. Domel 12. Munda
4. Palak 13. Warsak
5. Mangla 14. Kurrum Garhi
6. Rohtas 15. Gulkutch
7. G.T. Road 16. Durband
8. Kalabagh 17. Chiniot
9. Mukhad 18. Shahdara
Indus R.
Jhelum R.
Chenab R.
Ravi R.
Sutlej R.
Beas R.
Gomal R.
Zhob
Marala
H viest Soil Erosion.
Order 10,000 to 6,000 tons/sq mile
Extensive soil erosion, needs extensive soil conservation, order 4.000 to 6.000 tons/sq mile
Erosion from disintegrated rocks, little amount of soil, order 3,000 to 4,000 tons/sq mile
Erosion from rocks.
Order 2,000 to 3,000 tons/sq mile
Erosion of soil cover, order 1,000 to 2,000 tons/sq mile
Erosion from rocks.
Order up to 1,000 tons/sq mile

TABLE

Statement showing sediment

Serial No.	River	Site	Catchment area in sq. miles up till site.	Average discharge in M. A. Ft.	Sediment: Sand	Silt	Clay	Total
1	2	3	4	5	6	7	8	9
1	Indus ..	Durband ..	63600	59·5	45832	24451	15138	85421
2	Siran ..	Thapla ..	1100	0.141	88·1	548·8	27.1	664
3	Kabul ..	Warsak ..	26000	12·9	14893	6445	3403	24742
4	Swat ..	Munda ..	4810	2·86	556	1400	458	2424
5	Harrow ..	G. T. Road	2400	0·82	26.1	968.4	50·3	1044 8
6	Soan ..	Mukhad ..	4800	0·8	463·3	4317 9	153	4934·2
		Total ..	102710	77.021	61878·5	38131·1	16176·7	128733·2
7	Indus ...	Kalabagh ..	103800	89.0	58919	68134	16691	143744
8	Kurrum ..	Kurrum Garhi	2633	0.97	3745·5	8800·7	330.9	12878·3
9	Gomal ..	Gulkach ..	15400	0.927	408·5	183·8	8·6	550·4
		Total ..	121483	89·997	62674·0	77068·3	17030·5	157172·7

NO. 1

of Indus and its Tributaries.

IN A.FT.								
Bed load at 20% suspended.	Total sand bed load +sand	Silt + Clay	Total sediment with bed load.	% of sed./discharge with bed load.	Total sediment in M. tons including bed load.	Sediment in tons for sq. miles.	Erosion in ft. for sq. miles 10^{-4}/yr.	Remarks
10	11	12	13	14	15	16	17	18
17085	62937	39589	102506	0·172	179·38	2820	25·0	
133	221·1	575·9	779	0·565	1·37	1250	11·3	
4948	19841	9848·3	29690	0·225	51.95	1998	18·0	
485	1041	1868	2909	0·102	50·90	1058	9·5	
208·9	235·0	1018·7	1254	0·153	2·19	915	8·3	
987	1450·3	4470·9	5721·2	0·74	9·36	1950.4	17.6	
23846·9	85725·4	58070·8	144077·2	0·2	295.16	1427	..	% sed./ Discharge in column 14 is the Ratio of 13 to 5.
28749	87668·0	84825	172493	0·193	301.36	2908	26.2	
2576	6321·5	9131·6	15454·3	1·59	27.04	10272	92.5	
110	518·5	142·2	660	2·44	1·15	75	0.675	
31438	94508·0	94099·8	187947·3	0·2	330.07	..	..	

TABLE

Statement showing sediment

Sl. No.	River	Site	Catchment area in sq. miles up till site.	Average Dis. in M.A. Ft.	Sediment Sand	Silt	Clay	Total
1	2	3	4	5	6	7	8	9
1.	Jhelum	Domail	5280	11.42	3002.0	3710.0	1765.0	8477
2.	Kishan Ganga	Muzaffarabad.	2600	6.42	1998	1485	869	4883
3.	Kunhar	Garhi.	1080	2.06	994	1031	325	2350
4.	Poonch	Palak.	1520	2.53	1475	2055	656	4186
5.	Kanshi	G.T. Road.	696	0.03	11.1	224.1	3.7	238.9
		Total:	11176	22.46	7430.1	8505.1	2618.7	19604.9
6.	Jhelum	Mangla.	13180	24.9	15500	16584	4742	36827
7.	Kahan	Rohtas.	470	0.04	19.1	305.5	28.6	353.2
		Total:	13650	24.04	15519.1	16889.5	4770.6	37180.2

NO. 2.

of Jhelum and its Tributaries.

IN A. Ft.				% of Sed·/ dis. with bed load.	Total sediment in M. tons including bed load	Sediment in tons for sq. miles	Erosions in ft. for sq. miles 10-4/Yr.	Remarks
Bed load at 20% suspended	Total sand bed load +sand.	Silt+ clay.	Total sediment with bed load.					
10	11	12	13	14	15	16	17	18
1695	4797.0	5475.0	10172	0.089	17.80	3371	32.0	
871	2869	2354	5224	0.081	9.142	3516	31.6	
470	1464	1356	2820	0.137	4.935	4569	41.0	
837	2312	2711	5023	0.198	8.790	5783	52.0	
47.8	58.9	227.8	2877	0.957	0.502	722	6.5	
3870.8	14440.9	12123.8	26116	0.1	41.169			% sediment to discharge in Column 14 is the Ratio of Column 13 to 15.
7365	22865	21326	44192	0.18	77.336	5868	52.8	
70.6	89.7	334.1	423.8	1.06	0.742	1578	14.2	
7435.6	22954.7	21660.1	44615.8	0.19	78.078	7446		

TABLE

Statement showing

S. No.	River	Site	Catchment area in sq. miles up till site.	Average dis. in M.A. Ft.	Sediment			
					Sand	Silt	Clay	Total
1	2	3	4	5	6	7	8	9
1.	Chenab ..	Chiniot ..	26078	14.3	13435.0	14102.5	4115.7	31653.2
2.	Ravi ..	Shahdara ..	3123	11.6	635.3	19332.4	5530.0	25497.7
3.	Bias ..	Balahue ..	2320	9.0	..	..	...	4924.0
4.	Sutlej ..	Bhakra ..	21965	16.0	...	..	..	19600

NO. 3.

Sediment observation Data.

IN A. FT.

Bed load at 20% suspended.	Total sand bed load + sand.	Silt + Clay	Total sediment with bed load	% of sed./dis. with bed load.	Total sediment in M. tons including bed load	Sediment in tons for sq. miles.	Erosion in tons for sq. miles. 10^{-4}/yr.	Remarks.
10	11	12	13	14	15	16	17	18
6331	19766	18218.2	37984	0.265	66.47	(1) 2549 (2) 4228	(1) 20·0 (2) 38.0	(2) Values are after including sediment load of withdrawal and of Floods.
5099	5734.3	24862.4	30596.7	0.263	53.54	17145	150	Data is for 18th July to 10th October, 1959.
845	..	...	5069	0.013	8.87	3824	30	
3920	...	...	23520	0.261	41·16	1875	16	

RECENT CLIMATIC FLUCTUATION OVER SOUTH ASIA & THE INDIAN OCEAN

BY

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Introduction.

A number of studies have appeared in recent years on the extent and magnitude of the present climatic fluctuation. Some important contributions have been made by Kincer (1), Brooks (3), Lysgaard (6), Rubinstein (8), Willet (9), Ahlmann (11), Scherhag (13), Groismayer (14) Kraus (18), Petterssen (20) and Brezowsky (21). Regional investigations are both extensive and intensive but most of these deal with the N. American or European Space. Although some elaborate studies exist on Bharat and Pakistan especially those of Pramanik and Jagannathan (22), to the best of this author's knowledge no study of this nature has been undertaken so far which deals with the monsoon realm of S. Asia as a whole. It is the object of this paper to accomplish this purpose as far as possible. Only the preliminary results are reported here and they too very briefly. As such no attempt is made to theorize or to produce a detailed argument on the physical interpretation of the results. Nevertheless, a few tentative remarks in this connection may be found here and there.

Methods & Data.

The study is based on the examination of decennial departures and inter-quintile differences of atmospheric pressure, temperature and precipitation. The method is not without its disadvantages but for a preliminary study like this it was not considered unsuitable. Linear and parabolic regressions are being fitted to the series and the results will be reported in a later paper.

The data have been derived from the WWR upto 1940. For years after 1940 and for stations not given in the WWR the data have been obtained by correspondence and the writer wishes to express his deep gratitude to all those who have contributed in this respect.

1. **Air-Pressure.**

A study of the decadal variations shows (see Maps 1—6) that the air pressure during the decade 1881-90 was on the whole above the average. The Equatorial Trough witnessed a positive departure of >0.02 inches. It was also higher over S.E. Asia, Soviet Turkish Republics, Middle East and the Arabian Sea. The Siberian anticyclone was weak and the pressure showed a negative anomaly over N. China, Tibet and Ladakh. Central Bharat and Ceylon also experienced a small decrease. During the following decade, the essential features of the pattern almost remained the same except for a decrease of pressure over West Pakistan and Tajakistan and eastern parts of Uzbekistan and Turkomanistan. The positive anomaly over the Middle East was intensified. China and Tibet also showed an increase of pressure. The decade 1901—10 showed the culmination of rising trend in the Equatorial Trough (>0.03 inches) and the Middle East (>0.02 inches). Northern Bharat and West Pakistan also showed considerable increase of pressure. The Siberian centre of action was weak and the pressure showed a remarkable decline in its regime. The only other parts showing a similar tendency were Southern Bharat and Ceylon.

During the period 1911—20, the region under study was almost equally divided between the positive and negative departures. The distribution pattern pertaining to this period resembled the preceding one with the important difference that the positive departure in the Equatorial Trough passed into negative. The Siberian H.P. was still weak and a ridge of high pressure ran across the Middle East, Pakistan, Bharat and the Bay of Bengal seperating the negative anomalies of Central Asia and China from those of the Equatorial Trough and the Arabian Sea. The change from a rising to falling tendency in the region of I.T.C. seems to have preceded the analogous change in the South Asian L.P. by at least a decade as should be expected from the northward propagation of the Southern Oscillation.

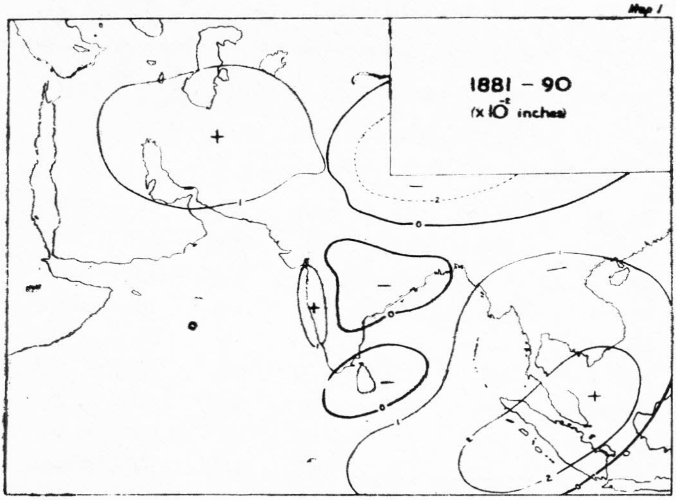
For the region as a whole the period 1905—15 was a turning point in the secular variation. It marked the peak of rising trend in the South Asian centre of action and the lowest ebb in the activity of the Siberian H.P. It is also evident from the behaviour of the two cells that the period marked the end of the north-steering process which terminated earlier in the I.T.C.Z. Following this decade as the South Asian L.P. grew weaker and weaker, the Siberian H.P. gradually built itself up and the steering operation was reversed.

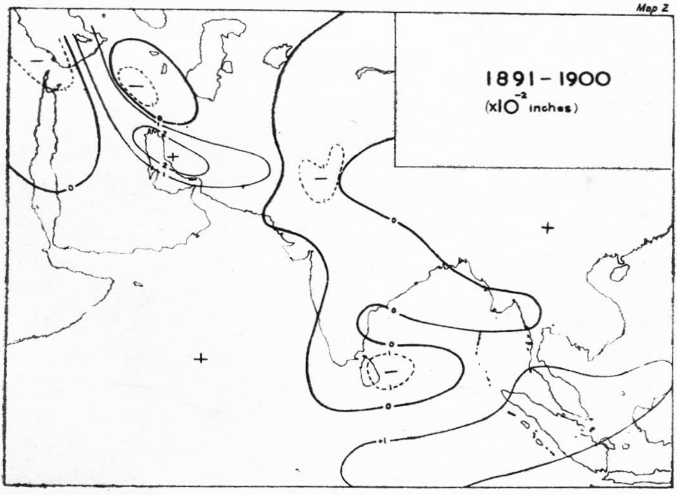
The decade 1921—30 recorded an appreciable increase of pressure in the regime of Siberian H.P. i.e. China, Tibet, Ladakh and S.E. Asia. A longitudinal ridge also extended over Central and South Bharat. Another notable increase of pressure was observed over the northern sector of the Middle East centred over Baghdad. A negative correlation between Baghdad and Bushire is striking as may be seen from an examination of the charts. The fact seems to be probably connected with the changes in the tracks of the western disturbances. But the point needs thorough investigation before any conclusion can be drawn about the nature of this correlation.

TABLE 1

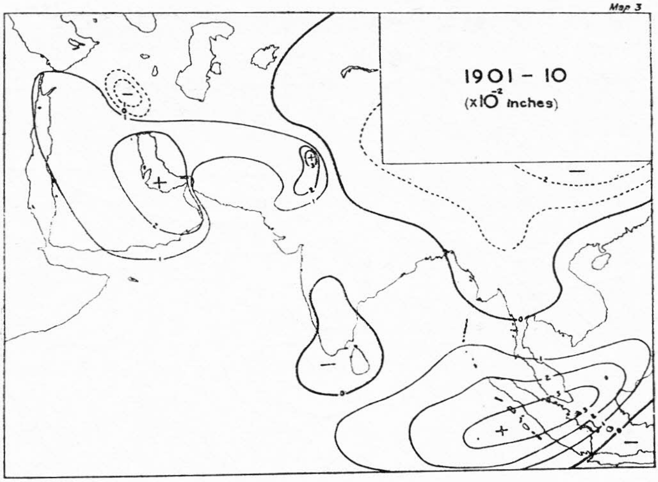
Decade Averages of Annual Pressure (inches of Mercury)

	Mean	1871—1880	1881—1890	1891—1900	1901—1910	1911—1920	1921—1930	1931—1940	1941—1950
Aden	29.755	—	.758	.754	.763	.752	.753	.752	—
Akyab	29.808	.814	.818	.809	.805	.805	.795	.809	—
Alexandria	30.327	—	—	.312	.336	.336	.328	.324	—
Allahabad	29.471	.473	.478	.469	.476	.471	.468	.465	456
Bagdad	29.767	—	—	.752	.751	.753	.811	—	—
Banglore	26.881	.885	.881	.874	.876	.885	.885	.879	878
Beirut	30.281	.298	.293	.296	.286	.284	.257	.250	—
Bombay	29.808	.810	.819	.812	.811	.805	.803	.801	.789
Bushire	29.813	—	.821	827	.821	.815	.812	.792	—
Calcutta	29.773	.776	.772	.773	.777	.774	.769	.767	.761
Cochin	29.860	—	.861	.856	.860	.856	.861	.861	.849
Colombo	29.826	.825	.823	.823	.823	.850	.816	.823	.819
Hankow	30.413	—	—	—	.380	.384	.452	.436	—
Hongkong	28.900	.907	.902	.902	.902	.897	.897	.897	.904
Jaipur	28.372	—	.373	.370	.376	.370	.378	.365	—
Jakarta	30.271	—	.263	.274	.273	.269	.275	.271	.265
Jask	29.804	—	—	.813	.808	.801	.799	.796	—
Karachi	29.805	.810	.802	.800	.814	.810	.804	.794	.772
Krasnovodsk	30.567	—	.580	.572	.568	.560	.560	.564	.560
Lahore	29.062	.067	.069	.066	.067	.068	.061	.061	.061
Leh	19.675	.678	.663	.676	.667	.675	.679	.684	—
Madras	29.815	.819	.820	.817	.814	.812	.806	.802	—
Muscat	29.805	—	—	—	.822	.831	.794	.792	—
Nagpur	28.780	.768	.775	.777	.786	.788	.789	.779	.765
Quetta	24.569	—	.568	.587	.587	.584	.584	.560	.539
Phu Lien	29.938	—	—	—	—	.937	.938	—	—
P. Blair	29.777	.763	.787	.778	.786	.779	.770	.773	—
P. Victoria	29.855	—	—	.861	.858	.853	.854	.851	—
Rangoon	29.830	.835	.839	.826	.828	.836	.830	.818	—
Saigon	30.251	—	—	—	—	.250	.252	—	—
Shillong	25.074	—	—	—	.068	.074	.081	.074	—
Singapore	29.854	.860	.878	.863	.887	.836	.833	.810	—
Simla	23.053	—	.044	.047	.049	.057	.060	.058	—
Tashkent	28.834	.880	.836	.828	.832	.824	.824	.824	.812
Tbilisi	29.095	—	.100	.096	.096	—	.096	.088	—
Trincomalee	29.677	29.677	.674	.667	.666	.676	.684	.685	.690
Vizagapatam	29.770	29.770	.775	.770	.767	.775	.777	.786	.760


1881 - 90
(x 10^{-2} inches)


1891 - 1900
(x10^{-2} inches)

Map 3



Map 4

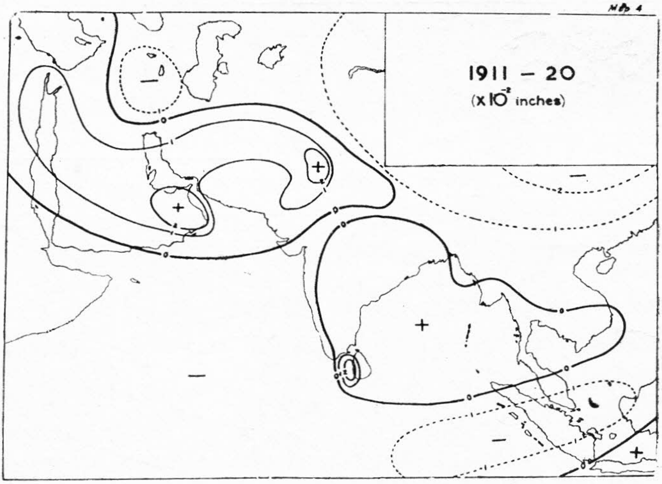


TABLE 2

Showing the Decadal & Quintile variations of Annual Air-pressure in Siberia (700 mm.+)

	Irkutsk 52 N	Tomsk 56 N	Yenisseysk 58 N
1881-90	20.0	52.3	—
1891-1900	22.7	52.6	55.8
1901-10	22.3	52.5	55.3
1911-20	22.2	52.0	55.3
1921-30	22.1	52.3	56.1
1931-40	22.3	52.7	56.3
1881-1900	22.4	52.5	55.8
1901-30	22.2	52.4	55.6
1931-40	22.3	52.7	56.3
1881-1930	22.3	52.5	55.7
1931-40	22.3	52.7	56.3
△	0.0	+0.2	+0.6

The period 1931—40 may be termed catastrophic in the sense that the amplitude of variation was very high both in the regime of the Siberian H.P. (‡>+0.04‡) and the Equatorial Trough (‡>—0.04‡). The S. Asian L.P. also showed intensification of falling tendency although the amplitude of variation was half that of the I.T.C.Z. The pressure was also below the average over the Central Asiatic Soviet Republics. Table 2 will indicate that the pressure rise over Siberia took about a decade to appear at Irkutsk, 4° south of the centre of H.P. This was most probably due to south-steering. Because of the inaccessibility of data for the Soviet stations for the latter period, the writer is unable to show the further progress of steering in this region.

The data for the period 1941—50 are not adequate to draw the anomalies over the whole region. A further decrease of pressure in the South Asian L.P. is however evident from the data of this decade given in Table 1. This seems to have been balanced by a corresponding increase in the Siberian centre of action. The data for the period 1951—56 for a limited number of stations available to the writer in the South Asian region show an increase of pressure as compared with the preceding decade.

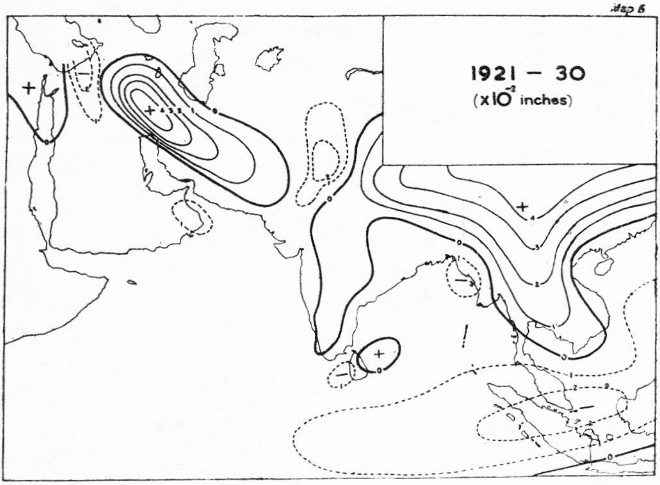
An important point not hitherto mentioned is the negative correlation between the opposing shore-lines which is also brought out clearly by an examination of the decennial charts. This appears to be due to the seasonal contrasts inherent in the dynamical

TABLE 3

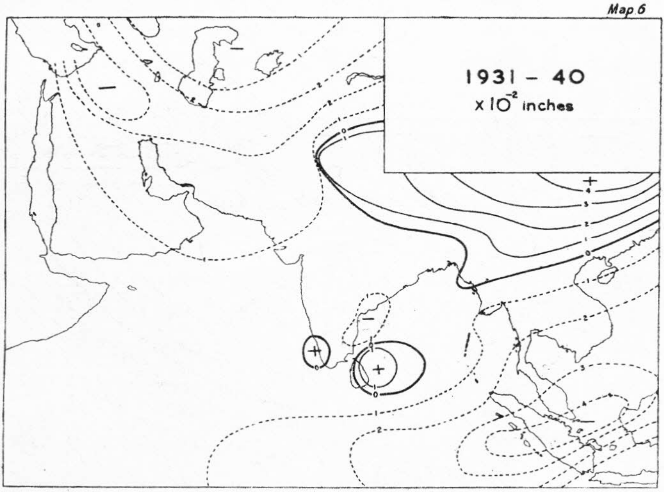
Quintile Averages & Inter-Quintile Differences of Air-Pressure (inches of Mercury)

Station	1871/1900	1901/30	1931/50	1901/30—1871/1900	1931/50—1901/1930	1931/50—1871/1930
Aden	.756	.756	.752	0	—.004	—.004
Akyab	.813	.802	.809	—.011	+.007	+.002
Alexandria	.312	.333	.324	+.021	—.009	+.002
Allahabad	.473	.472	.460	—.001	—.012	—.012
Bagdad	.752	.738	—	—.014	—	—
Banglore	.880	.882	.879	+.002	—.003	—.002
Beirut	.296	.276	.250	—.020	—.026	—.036
Bombay	.813	.806	.790	—.007	—.016	—.020
Bushire	.824	.815	.792	—.008	—.024	—.028
Calcutta	.773	.772	.764	—.001	—.008	—.008
Cochin	.858	.860	.855	+.002	—.005	—.004
Colombo	.824	.830	.820	+.006	—.010	—.007
Gilgit	—	.107	.143	—	+.036	+.036
Hankow	—	.405	.436	—	+.031	+.031
Hongkong	.905	.899	.900	—.006	+.001	—.002
Jaipur	.371	.375	.358	+.004	—.017	—.015
Jakarta	.270	.272	.265	+.002	—.007	—.006
Jask	.813	.809	.796	—.004	—.013	—.015
Karachi	.804	.809	.781	+.005	—.028	—.025
Krasnovodsk	.576	.564	.560	—.012	—.004	—.010
Lahore	.067	.065	.050	—.002	—.015	—.016
Leh	.672	.670	.684	—.002	+.014	+.013
Madras	.819	.810	.802	—.009	—.008	—.013
Muree	.158	.146	.142	—.012	—.004	—.010
Muscat	—	.816	.972	—	—.024	—.024
Nagpur	.773	.788	.772	+.015	—.016	—.008
Quetta	.578	.585	.548	+.007	—.037	—.033
P. Blair	.776	.775	.773	—.001	—.002	—.002
P. Victoria	.861	.855	.851	—.006	—.004	—.007
Rangoon	.833	.831	.818	—.002	—.013	—.014
Shillong	—	.074	.074	—	0	0
Singapore	.870	.852	.810	—.018	—.042	—.051
Simla	.045	.055	.058	+.010	—.003	+.008
Tashkant	.848	.827	.812	—.021	—.015	—.015
Tbilisi	.098	.096	.088	—.002	—.008	—.009
Trincomalee	.672	.682	.690	+.010	+.008	+.013
Vizagapatam	.771	.773	.758	+.002	—.015	—.014

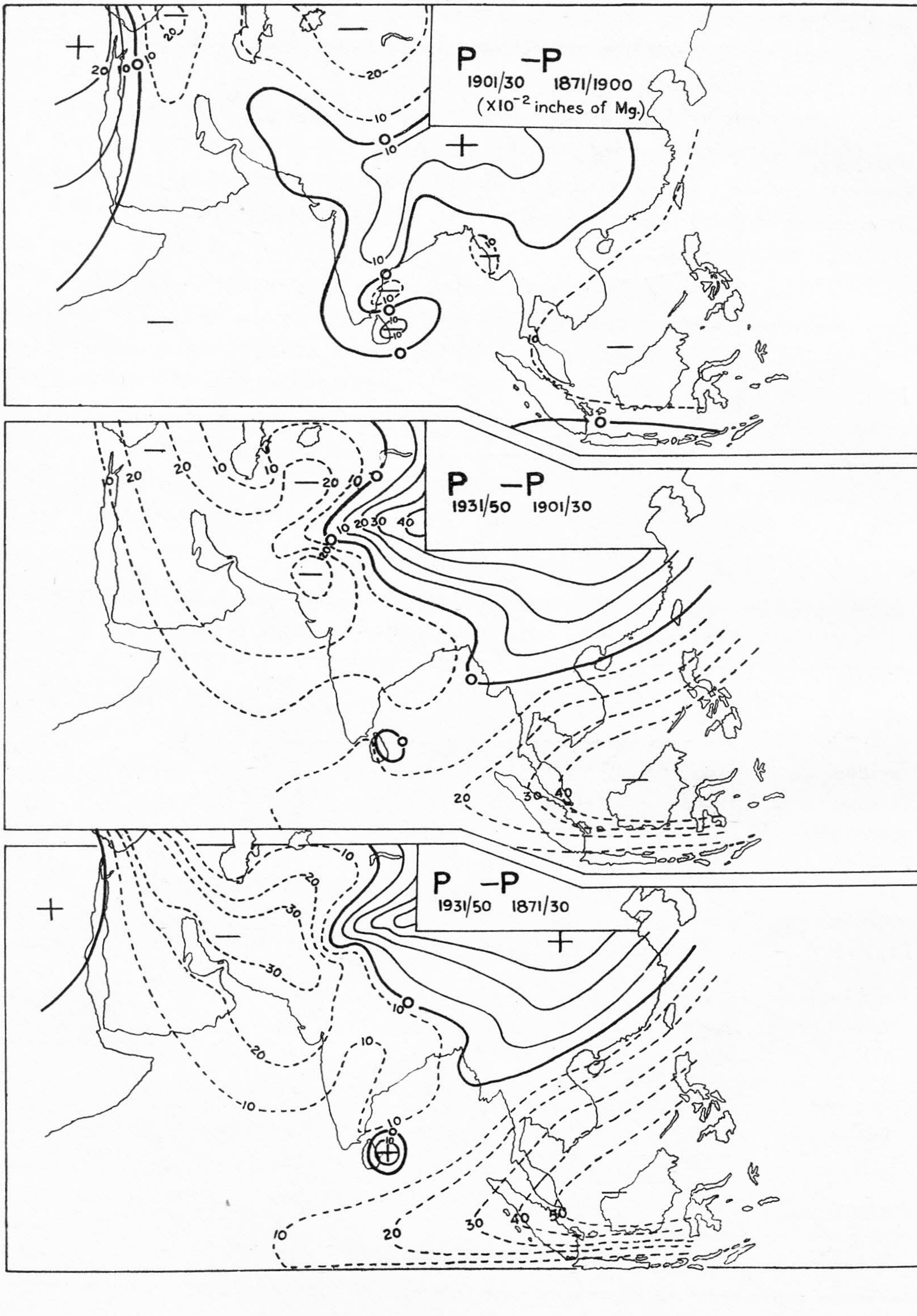
Map 6



Map 6



MAP 7



P 1901/30 −P 1871/1900
(X10⁻² inches of Mg.)
P 1931/50 −P 1901/30
P 1931/50 −P 1871/30

climatology of the area. In the winter season the eastern coasts are under the impact of the onshore N.E. Monsoon so that the pressure variations along these coasts are largely controlled by the conditions in the Siberian H.P. In the summer season the conditions are reversed and these are the western coasts which come under the onshore S.W. Monsoon. Consequently the pressure conditions along these coasts are largely governed by the variations in the overall strength of the S.W. monsoon current. The negative correlation between the opposing shorelines is therefore another manifestation of the identical correlation between the Siberian H.P. and the South Asian L.P.

An apparent anomaly in this respect needs some explanation. This is the opposing trend between the Eastern Ghats and the eastern coast of Ceylon. It seems to be most probably connected with the fluctuations in the autumnal position of the I.T.C.Z. which is the most important single factor in the dynamical climatology of that region. During this period the eastern coast of Ceylon is still under the influence of the offshore equa ional westerlies which as they enter the Bay of Bengal are deflected westward under the pressure forces and become onshore on the Eastern Ghats. A southerly displacement of the I.T.C.Z. would bring these onshore winds to

TABLE 4

Showing the Decadal & Quintile variations of annual air-pressure in the South Asian L. P. & the surrounding anti-cyclonic centres of action (700 mm. +)

Period	*South Asian L.P. (Lahore)*	*Siberian H.P. (Tomsk)*	*Azors H.P. (Ponta Delgada)*	*Ogasawara H.P. (Honolulu)*
1871-80	26.7	—	—	—
1881-90	26.7	52.3	—	49.4
1891-1900	26.6	52.6	65.3	49.7
1901-10	26.7	52.5	66.3	49.6
1911-20	26.7	52.0	66.1	49.6
1921-30	26.5	52.3	66.1	49.6
1931-40	26.5	52.7	65.9	49.3
1871-1900	26.7	52.5	65.3	49.6
1901-30	26.6	52.4	66.3	49.6
1931-40	26.5	52.7	65.9	49.3
1871-1900	26.7	52.5	65.3	49.6
1901-40	26.6	52.6	66.11	49.5
△	−0·1	+0.1	+0.8	—0.1
1871-1930	26.7	52.5	65.8	49.6
1931-40	26.5	52.7	65.9	49.3
△	—0.2	+0.2	+0.1	—0.3

the Eastern coast of Ceylon and place the Madras coast under the influence of the retreating monsoons which are either offshore or parallel to the coast. An opposing trend between the two regions is therefore a natural expectation.

Table 3 shows the quintile averages and the inter-quintile variations of air-pressure. The latter values are also charted on Map 7. The last quintad is not complete and gives the data only for the period 1931-50.

A study of Map 7 reveals that the pressure during the quintad 1901-30 (the Standard Period) was above the pressure of the preceding quintad over China, Tibet and most parts of Bharat and Pakistan. Other areas showing similar trend were N. E. Africa and Indonesia (excluding Sumatra). During the period 1931—50, the pressure increase intensified in the regime of the Siberian H.P. and the eastern coast of Ceylon and decreased over the rest of of the region under study. The highest rise was observed over China and lowest fall over the Central regions of the middle East.

It has been pointed out earlier that whereas the S. Asian L.P. and the Equatorial Trough have a positive correlation, the S. Asian L.P. and the Siberian H.P. act in the opposite direction. It may be seen from Map 8 that in the Northern Hemisphere the South Asian L.P. is surrounded by five other centres of action. The correlation analysis reveals that the South Asian L.P. has a positive correlation with Ogasawara H.P., the Iceland and the Aleutions L.P. and negative correlation with the Azores and Siberian H.P. It is therefore not surprising to find that the steering process in the Asiatic region is always opposite to that in the N. Atlantic and Europe (see Lysgaard (op.cit) and Schove, 23). Table 4 gives the decadal and quintile variations of the annual air-pressure in other centres of action of the Northern Hemisphere.

In conclusion it may be said that in the region under study the annual pressure was rising in the South Asian L.P. and the Equatorial Trough and falling in the Siberian H.P. since the beginning of the period to 1905—15. After this period the trend changed to one of increase in the Siberian H.P. and decrease in the S. Asian L.P. and the Equatorial Trough. This trend continued upto 1941—50. after which it showed signs of reversal to the previous trend.

2. Temperature

Table 7 contains the decadal averages of the mean annual temperature. The departures from the mean for each decade are charted on Maps 8 to 13. A study of these maps reveals the following salient features of secular variation.

The decade 1881-90 recorded an increase of temperature over the Equatorial Trough, the Bay of Bengal, Ladakh and Sinkiang. It was also above the average over

TABLE 5

Inter-Decadal differences of annual air-pressure over the Soviet Turkish Republics and the Middle Eastern Countries (mm)

Period	*Alma Ata*	*Tashkent*	*Krasnovodsk*	*Bushire*	*Beirut*	*Aden*
1871-80	—	722.0	—	—	757.5	—
1881-90	695.9	+0.9	764.5	745.5	—0.2	744.0
1891-1900	+0.5	—0.2	—0.3	+0.2	+0.1	—0.1
1901-10	—0.2	+0.1	—0.1	—0.2	—0.2	+0.2
1911-20	—0.1	—0.2	—0.2	—0.1	—0.1	+0.3
1921-30	—0.1	0.0	+0.1	—0.1	—0.7	0.0
1931-40	0.0	—0.3	—0.5	—0.5	—0.1	0.0

TABLE 6

Inter-Decadal differences of annual air-pressure in the Equatorial Trough of the Indian Ocean.

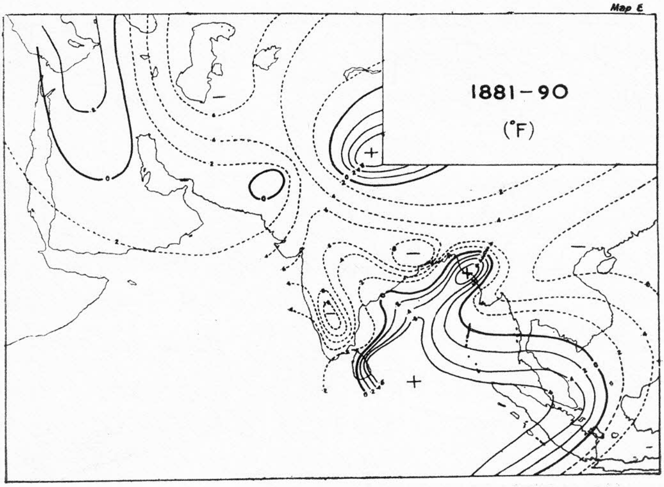
Period	*Zanzibar*	*P. Victoria*	*Singapore*	*Jakarta*
1861-70	—	—	—	756.9
1871-80	—	—	746.5	—0.3
1881-90	—	—	+0.5	+0.3
1891-1900	747.9	746.5	—0.4	—0.1
1901-10	0.0	0.0	+0.6	—0.1
1911-20	+0.4	—0.2	—1.2	+0.2
1921-30	—0.4	+0.1	—0.2	—0.1
1931-40	0.0	—0.1	—0.5	—0.2

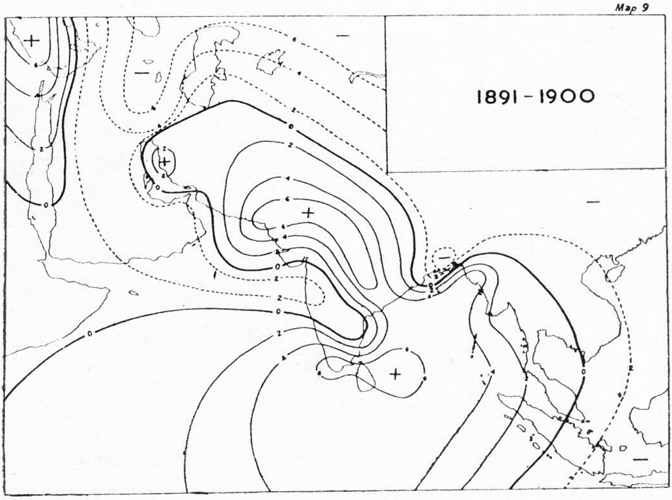
Lebanon, Syria, Jordan, Israel and parts of Turkey, Saudi Arabia, Iraq and W. Pakistan. Rest of the region under study showed a marked decline of temperature. The thermoplions were situated over the Bay of Bengal and Sinkiang and the thermomeons over W. Bengal and Andhra Paradesh. During the following decade, the rising trend in the Indian Ocean invaded large parts of the Indo-Pakistan sub-continent, Iran and Afghanistan. A similar rise of temperature was also recorded over Egypt and Sudan. Over other parts of the Middle East and the Soviet Republics of Turkomania, Tajkia, Uzbekia and Kazakia as well as over Tibet and China temperature showed a marked decline. The trend was in complete conformity with the similar trend in Siberia as will

TABLE 7

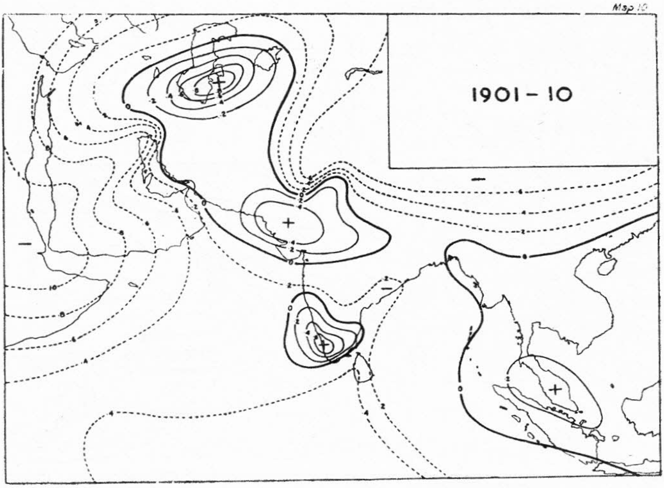
Decennial Averages of Annual Temperature (°F)

	Mean	1871—1880	1881—1890	1891—1900	1901—1910	1911—1920	1921—1930	1931—1940	1941—
Aden	83.2	—	82.9	83.1	82.1	82.7	83.3	84.4	84.3
Akyab	78.6	—	79.3	79.1	78.7	78.1	78.1	78.2	—
Alexandria	68.5	67.1	68.5	69.1	67.6	68.7	69.6	69.4	—
Allahabad	78.6	78.9	78.0	78.9	78.6	78.4	79.0	78.1	79.2
Bagdad	72.9	—	—	72.2	73.9	72.8	72.8	—	—
Banglore	74.6	74.6	73.6	74.6	74.6	74.8	75.3	75.0	74.5
Basra	75.5	—	—	—	74.9	75.3	76.3	—	—
Beirut	70.0	71.4	70.3	69.8	69.6	69.4	70.7	70.9	—
Bombay	80.7	—	80.0	80.5	80.6	81.0	81.0	81.2	81.2
Bushire	75.2	—	75.1	75.4	75.2	74.8	75.4	75.4	75.6
Calcutta	79.1	—	78.3	78.7	79.0	79.2	79.7	80.0	80.3
Cochin	81.0	80.6	80.7	81.6	81.6	81.4	80.8	80.6	—
Colombo	80.9	81.1	80.8	81.4	81.4	80.7	80.6	80.4	80.7
D.I. Khan	76.3	—	—	—	75.6	76.4	75.8	76.0	77.6
Hankow	62.4	—	—	—	61.7	61.9	63.5	62.9	—
Hongkong	71.9	—	71.3	71.6	72.0	72.0	72.1	72.3	—
Karachi	78.3	—	78.2	79.0	78.8	77.8	77.8	78.4	78.4
Jaipur	77.9	—	77.3	78.5	78.2	77.9	78.0	78.0	78.5
Jakarta	79.2	78.6	78.8	78.9	79.2	79.3	79.9	80.1	—
Jask	80.1	—	—	79.9	80.1	79.5	80.5	80.3	—
Jacobabad	81.0	—	—	81.3	81.1	81.2	80.5	80.5	81.0
Krasnovodsk	60.1	—	59.5	60.1	61.0	60.3	60.1	60.1	—
Lahore	75.8	76.0	75.4	76.0	76.0	75.7	758	76.2	75.5
Leh	42.3	—	43.0	42.2	41.6	42.4	42.2	42.2	—
Madras	83.1	83.1	82.8	83.1	83.1	83.4	83.3	83.1	83.4
Meshed	56.3	—	—	—	—	56.8	55.7	56.4	—
Nagpur	80.3	80.2	80.0	81.0	80.2	80.0	80.4	80.1	80.3
P. Blair	81.8	81.8	81.9	82.3	81.8	81.7	81.3	81.5	—
Quetta	58.7	—	58.8	59.1	58.7	58.8	58.7	58.6	58.5
Rangoon	81.3	81.2	80.9	81.4	81.3	81.0	81.6	81.6	—
P. Victoria	79.8	—	—	79.9	79.4	80.4	80.0	79.1	—
Shillong	61.7	—	—	—	61.7	61.6	61.7	61.8	—
Saigon	81.5	—	—	—	—	81.9	81.3	—	—
Simla	55.3	—	—	55.6	55.1	55.0	55.4	55.5	—
Singapore	80.4	80.0	79,9	80.4	80.7	81.3	80.4	79.9	80.1
Tashkent	56.1	56.8	55.8	55.8	55.6	56.3	56.5	55.6	—
Tbilisi	54.7	—	54.1	54.1	54.5	54.5	55.2	55.2	—
Trincomalee	82.6	82.0	83.2	83.3	82.4	83.9	81.8	82.0	—
Vizagapatam	81.3	—	—	81.8	81.0	81.2	81.6	80.8	81.2

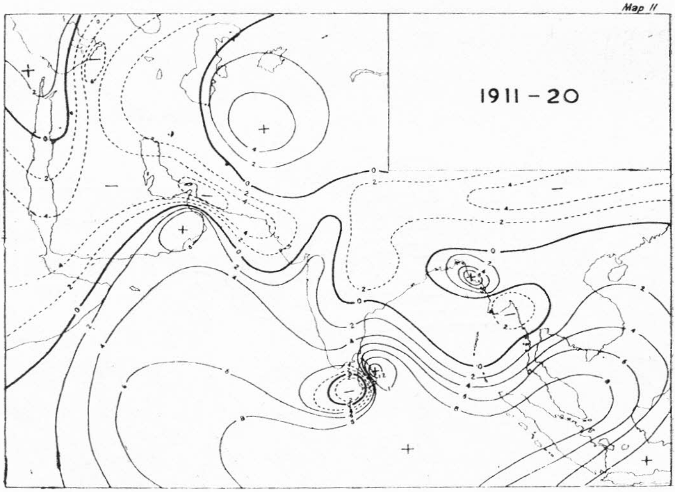

1881 – 90
(°F)


1891 - 1900

Map 10



Map 11



be seen from Table 8. The decade 1901-10 recorded a marked increase of temperature over Turkomanistan S.S.R., Iran, S.E. Asia and parts of the Indo-Pakistan sub-continent. The positive trend in the Equatorial Trough and N.E. Africa passed into negative. China and Tibet still showed decreasing trend in sympathy with the identical trend in Siberia.

The decade 1911-20 marked a turning point in the secular variation of temperature over Siberia. This will be appreciated by a study of the data for Tomsk and Irkutsk given in Table 9. Yenisseysk being situated on the N.E. margins of the Siberian centre of action seems to be influenced by the trends prevailing in both Siberian and Aleutions centres of action. It should be recalled that it was this decade which marked the change from a decreasing to increasing air-pressure in Siberia. The observed relationship between the two parameters agrees fully well with the theoretical considerations. This is primarily due to the fact that in a region like Siberia the contribution of complicating factors like insolation, advection and moisture is poor and the temperature field is largely controlled by the dynamical conditions i.e. high temperatures being associated with anticyclonic conditions and vice-versa.

TABLE 8

Showing the Decadal & Quintile variations of mean Annual Temperature in Siberia (°F)

Period	*Irkutsk* 52 N	*Tomsk* 56 N	*Yenisseysk* 58 N
1881-90	29.7	29.5	28.0
1891-1900	29.8	30.7	29.7
1901-10	29.5	30.7	28.9
1911-20	30.0	30.9	28.4
1921-30	30.6	32.2	28.9
1931-40	30.0	31.1	28.4
1881-1900	29.8	30.1	28.9
1901-30	30.0	31.3	28.7
1931-40	30.0	31.1	28.4
1881-1900	29.8	30.1	28.9
1901-40	30.0	31.2	28.6
△	+0.2	+1.1	—0.3
1881-1930	29.9	30.7	28.8
1931-40	30.0	31.1	28.4
△	+0.1	+0.4	+0.4

Although the change from a decreasing to increasing trend occured simultaneously over Siberia and Central Asia, its appearance was delayed over China and Tibet for about a decade. This is, however, in contrast to the general pressure tendencies in the area which seem to follow their parent trend in Siberia earlier in China than Central Asia. The apparent discrepancy requires thorough analysis of the other parameters.

The decade 1911-20 was on the whole characterized by an appreciable rise of temperature over most parts of the region under study. The Indian Ocean and the S.E. Asia recorded a high increase of temperature. Egypt and the Mediterranean also observed a similar increase. A narrow zone of negative anomalies with its longer axis along 30° N. Lat. separated the positive trends over the Central Asiatic Soviet Republics and the Mediterranean from those of the Indian Ocean, S. Bharat and S.E. Asia.

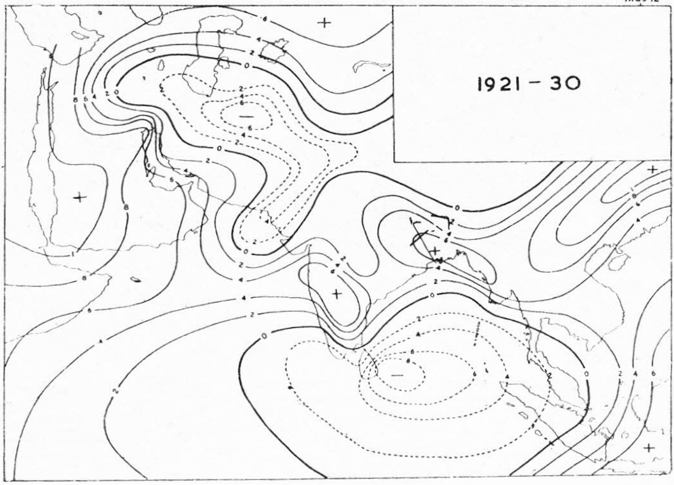
During the following decade (1921-30) the increasing trend in Siberia also appeared over China. Except for Eastern Indian Ocean, West Pakistan, Afghanistan and parts of Iran and Turkomanistan, the whole of the region under study experienced a major rise of temperature. During the subsequent decade the above trends continued to persist except over Central Asia where the positive trend passed into negative as well as in the Equatorial Trough which was now completely occupied by the negative anomalies. The change of trend in Central Asia from positive to negative, appears to have preceded a similar change in Siberia.

The data for the period 1941—50 are not complete to draw a chart of the anomalies for the whole region. A study of the departures for the data available shows no marked change from the trends of the previous decade. A general reduction of the amplitude of variation is however noticeable in the Indian Ocean in contrast to the large rise of temperature observed over the Middle East, Bharat and parts of West Pakistan. The quintile averages of temperature are given in Table 9 and inter-quintile variations are charted on Map 14.

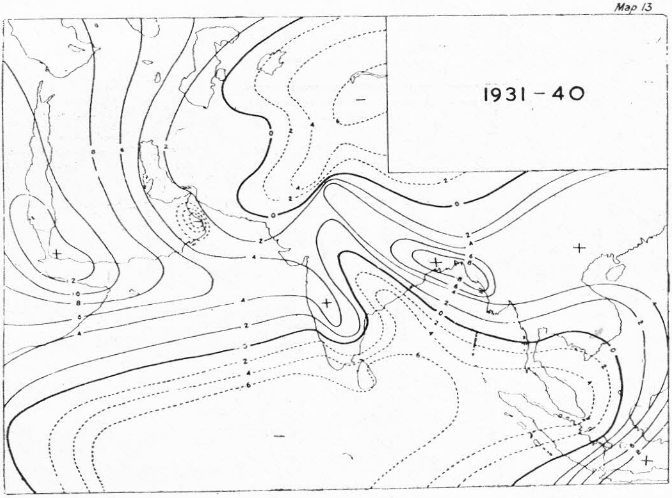
It is evident from the sequence of anomalies mentioned above that the temperature variations do not follow a regular pattern as was observed in the case of air-pressure. This is most probably due to the great seasonal contrasts inherent in the climatology of the area which result in a complicated interplay of major controls of radiation, advection, circulation and precipitation, thereby producing an erratic and confused behaviour of the thermal field. Nevertheless, it is still possible to pick up a few signals from this bewildering mesh of the meteorological noise.

It appears that following 1870 general decrease of temperature took place reaching its lowest ebb in the ninetees after which a steady reversal of the trend set in. This reaction was completed by 1911—20 after which temperatures continued to rise at least upto 1950. An opposite trend has been working over the Indian Ocean since about 1921.

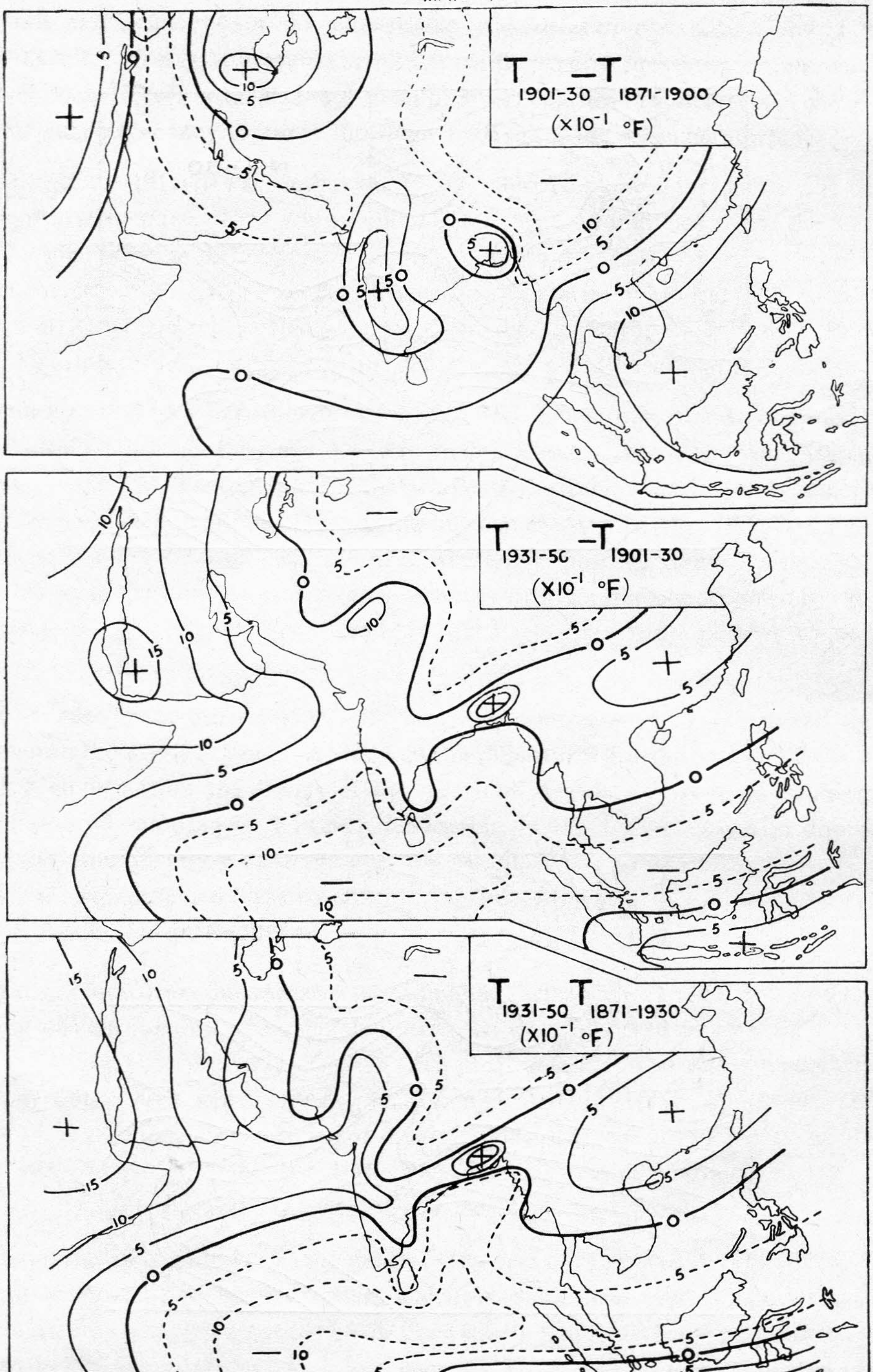
Map 12



Map 13



MAP 14



$T_{1901-30} - T_{1871-1900}$
($\times 10^{-1}$ °F)
$T_{1931-50} - T_{1901-30}$
($\times 10^{-1}$ °F)
$T_{1931-50} - T_{1871-1930}$
($\times 10^{-1}$ °F)

TABLE 9

Quintile Averages & Inter Quintile Differences of Annual Temperature (°F)

Station	1871-1900	1901-30	1931-50	2—1	3—2	3—1
	1	2	3			
Aden	83.0	82.7	84.4	—0.3	+1.7	+1·6
Akyab	79.2	78.3	78.2	—0.9	—0.1	—0.5
Alexandria	68.2	68.6	69.4	+0.4	—0.8	+1.0
Allahabad	78.6	78.6	78.1	+0	—0.5	—0·5
Bagdad	72.2	73.1	—	+0.9	—	—
Banglore	74·3	74.9	74.7	+0.6	—0.2	+0.1
Basra	—	75.5	—	—	—	—
Beirut	70.5	69.9	70.9	+0.6	+1.0	+0.7
Bombay	80.3	80.9	81.2	+0.6	+0.3	+0.6
Bushire	75.3	75.1	75.5	—0.2	+0.4	+0.3
Calcutta	78.5	79.3	80.2	+0.8	+0.9	+1.3
Cochin	80.9	81.3	80.6	+0.4	—0.7	—0.5
Colombo	81.1	80.8	80.6	—0.3	—0.2	—0.3
D.I.Khan	—	75.9	76.8	—	+0.9	+0.9
Hankow	—	62.3	62.9	—	+0.6	+0.6
Hongkong	71.5	72.0	72.3	+0.5	+0.3	+0.6
Karachi	78.6	78.1	78.4	+0.5	+0.3	+0.4
Jaipur	77.9	78.0	78.3	+0.1	+0.3	—0.4
Jakarta	78.8	79.5	80.1	+0.7	+0.6	+1.0
Jask	79.9	80.0	80.3	+0.1	+0.3	+0.3
Jacobabad	81.3	80.9	81.1	—0.4	+0.2	0
Krasnorodsk	59.8	60.5	60.1	+0.7	—0·4	0
Lahore	75.8	75.8	75.8	0	0	0
Leh	42.6	42.1	42.2	—0.5	—0.1	—0.1
Madras	83.0	83.3	83.3	+0.3	0	—0.1
Meshed	—	56.3	56.4	—	—0.1	+0.1
Muree	—	54.8	54.9	—	+0.1	+0.1
Nagpur	80.4	80.2	80.2	—0.2	0	+0.1
P. Blair	82·0	81.6	81.5	—0.4	—0.1	—0.3
Quetta	58.9	58.7	58.6	—0.2	—0.1	—0.2
Rangoon	81.2	81.3	81.6	—0.1	+0.3	+0.3
P. Victoria	79.9	79.9	79.1	0	+0.8	—0.8
Shillong	—	61.6	61.8	—	+0.2	+0.2
Saigon	—	81.6	—	—	—	—
Simla	55.6	55.2	55.5	—0.4	+0.3	+0.1
Singapore	80.1	80.8	80.0	+0.7	—0.8	—0.5
Tashkent	56.1	56.1	55.6	0	—0.5	—0.5
Tbilisi	54.1	54.7	55.2	+0.6	+0.5	+0.8
Trincomalee	82.8	82.7	82.0	—0.1	—0.7	—0.7
Vizagapatam	81.8	81.3	81.0	—0.5	—0.3	—0.5

The general warmth of the last four decades is most probably associated with the intensification of the Siberian anticyclogenesis. The opposite trend in the Indian Ocean since 1921 is also striking. Willet (op. cit.) is of the opinion that this may be due to some abnormal position or activity of the I.T.F. especially in the Northern Hemisphere, winter, perhaps, a more recent northward displacement. But the present writer feels that this is primarily due to the secular variations in the Southern Oscillation in which oceanic circulation plays the major role. Unfortunately long term data are not available for the South Indian Ocean but keeping in view the well known negative relationship of the climatic parameters over the South Pacific on the one hand and the Southern South Atlantic and the South Indian Ocean on the other (see Hildebrandson, 11, walker; 12, Tu; 13 & Berlage; 47), it is possible to reconstruct the sequence of changes in the region under discussion. An examination of the data around the western node of the curve of oscillation most clearly reveals a negative trend at Laurie Island, Grytviken and cape Pembroke on the Atlantic side and a positive trend at Puntas Arenas and Santiago on the Pacific side. The downward trend in the temperature of the Indian ocean since 1921 therefore agrees fully well with the trend in the Southern south Atlantic. This is exactly what should be expected on theoretical grounds.

3. **Precipitation.**

Table 10 shows the decadal averages of annual precipitation expressed as % of the mean rainfall at each station. The values are charted on Maps 15 to 20. A study of these charts reveals the following features.

The precipitation during the decade 1881—1890 was significantly high all over South Asia and especially over the Middle East. The only areas which showed negative anomalies were Central Asia, Tibet, parts of China and S.E. Asia. During the following decade the negative trend over the Central Asia, Tibet and Central China passed into positive but the identical trend over S.E. Asia expanded eastward to occupy the Bay of Bengal, S. Bharat and the Himalayas. Iran also recorded a major drop of rainfall during this period.

The decade 1901-10 witnessed a decreasing trend in the Indian Ocean, Lebanon, Iraq, South Iran, West Pakistan and large parts of Bharat. The increasing trend persisted over Saudi Arabia, Israel and Egypt. Northern Iran and Turkomanistan also showed increase of precipitation. During the following decade the pattern of anomalies was confusing. The rainfall was significantly below average over Egypt, Saudi Arabia, Western Ghats, Ceylon and the Indian Ocean. Similar trend also prevailed over China, Tibet and Central Asia. Iraq, S. Iran, Oman and Northern parts of West Pakistan recorded a good increase of rainfall. Western Burma and Malaya also showed a similar trend.

The period 1921—30, was on the whole, 'wet' for the region. Barring the Levant, Iraq and parts of Iran, W. Pakistan and Bharat the whole region under study recorded above-average rainfall. A slight decrease was also observed over eastern parts

TABLE 10

Showing the Decennial Average of Precipitation expressed as % of the mean

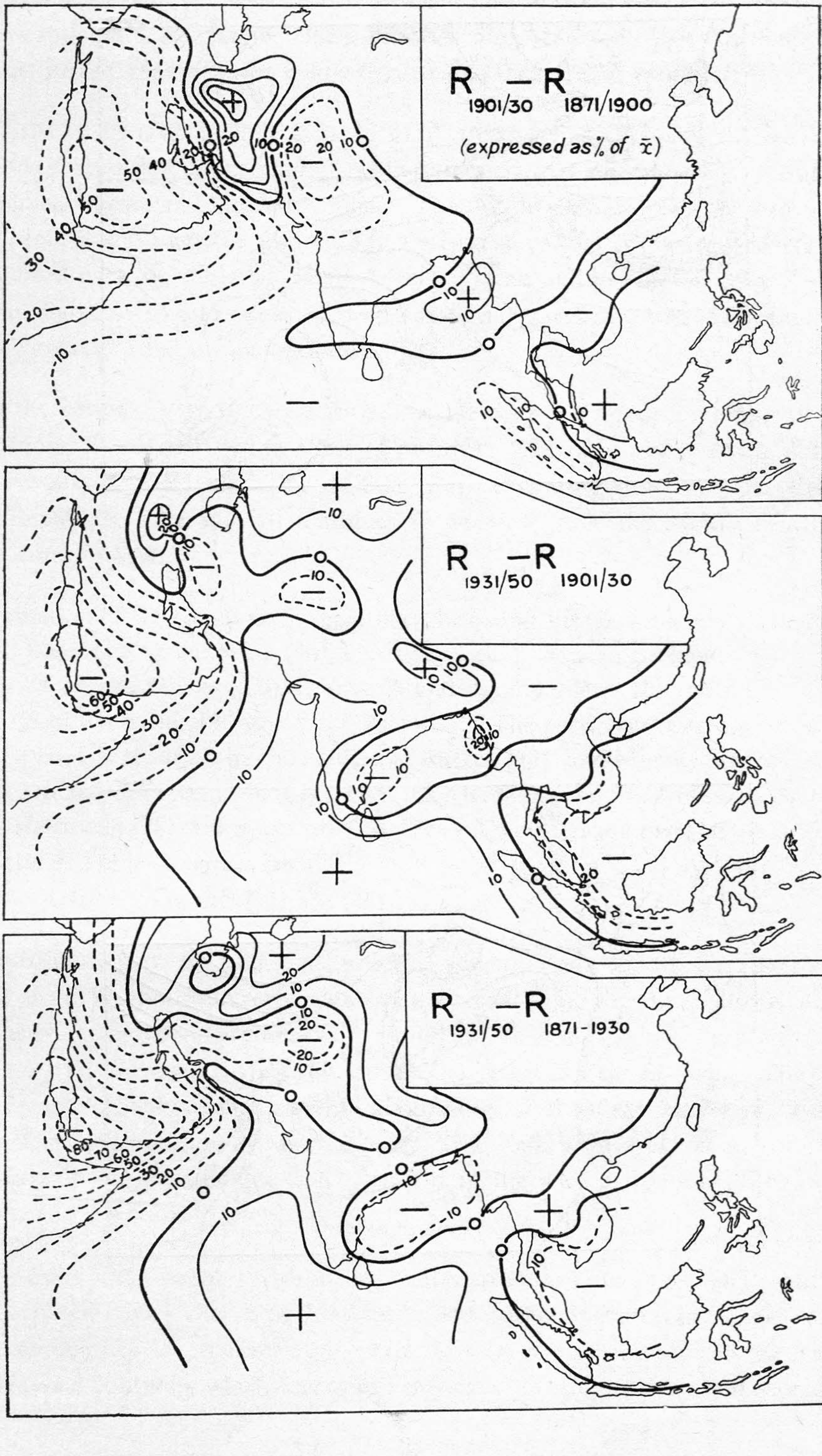
	1871-1880	1881-1890	1891-1900	1901-1910	1911-1920	1921-1930	1937-1946	1941-1950
Aden	—	216.42	116.42	148.57	69.28	140.71	87.1	85.71
Akyab	91.39	90.94	95.79	103.31	120.02	106.79	91.07	—
Alexandria	—	—	120.75	11.61	87.85	101.82	77.81	—
Allahabad	89.34	103.80	111.77	91.95	96.67	101.99	98.69	—
Bagdad	—	—	117.42	70.27	105.10	92.79	114.71	—
Bangkok	—	—	—	—	87.07	102.32	91.01	104.52
Banglore	103.64	100.65	90.77	106.07	105.30	90.94	98.56	—
Basra	—	—	—	86.41	102.40	80.07	102.45	—
Beirut	107.69	98.08	104.00	100.50	103.52	92.47	93.74	—
Bombay	101.43	107.43	101.90	91.53	93.43	101.55	107.53	—
Bushire	—	125.98	107.22	80.69	86.09	107.59	92.40	—
Calcutta	111.56	100.91	94.52	99.01	100.30	96.70	97.95	—
Cochin	93.02	98.43	96.32	96.19	100.63	107.96	103.28	—
Colombo	91.09	102.23	100.91	83.43	79.15	112.54	112.10	99.42
Delhi	—	117.90	105.23	102.63	98.68	93.44	111.51	112.74
Hongkong	100.62	104.54	96.39	93.26	99.51	104.59	93.86	106.87
Ispahan	—	—	73.89	126.99	96.00	100.88	83.19	108.18
Jaipur	112.19	117.08	108.54	87.36	108.41	105.41	105.10	—
Jakarta	104.64	95.40	102.36	104.56	101.10	91.61	98.68	—
Jask	—	—	88.66	80.44	116.22	113.77	101.11	—
Jerusalem	101.65	122.27	121.45	111.38	102.39	69.71	84.98	85.39
Karachi	86.31	97.89	110.39	95.78	89.34	109.60	107.36	104.60
Krasnovodsk	—	95.58	116.91	112.74	111.51	93.13	70.09	—
Kuta Draja	—	105.02	105.51	95.30	95.62	95.94	94.64	—
Lahore	103.40	120.00	92.47	86.70	85.41	99.94	86.54	91.90
Leh	78.76	76.92	132.30	103.07	91.69	108.61	109.23	—
Madras	104.51	108.35	92.62	101.30	111.50	104.87	89.47	—
Mandalay	—	—	96.42	95.09	93.42	118.30	96.78	—
Multan	104.88	96.89	115.38	84.61	134.17	85.79	85.79	68.93
Muscat	—	—	139.13	86.95	123.36	92.11	104.07	55.43
Mergui	—	—	98.14	102.39	94.55	102.70	97.12	—
Meshed	—	—	82.13	109.44	89.21	113.63	109.65	—
Montgomery	97.69	103.00	87.68	110.21	117.31	94.79	89.18	98.39
Nagpur	97.56	108.77	102.15	103.84	103.73	93.91	109·21	101.68
Peshawar	154.53	94.93	104.16	107.18	107.38	102.72	100.60	81.46
P. Blair	96.88	102.15	95.50	107.61	94.62	98.25	105.37	—
Pnom Penh	—	—	—	97.45	105.26	104.49	92.64	—
P. Victoria	—	—	104.03	98.75	95.55	103.14	98.49	—
Rangoon	98.32	91.25	97.08	95.35	108.01	103.65	106.33	—
Rawalpindi	95.59	98.50	92.29	97.36	101.08	105.43	104.38	109.20
Saigon	—	—	—	108.43	89.31	102.25	—	—
Shillong	106.44	97.15	91.58	99.89	99.00	97.47	108.39	—
Sialkot	103.92	105.32	94.39	101.05	95.98	98.13	105.70	94.73
Singapore	96.98	89.39	100.36	102.56	11.55	108.75	90.45	—
Tashkent	88.25	95.85	106.61	99.01	91.13	110.54	108.50	—
Tbilisi	—	95.69	100.60	106.85	90.14	97.79	901.7	—
Teheran	—	—	97.79	111.25	87.08	111.25	104.41	90.28
Trincomalee	92.12	97.46	106.01	95·45	92.61	105.22	98.93	112.12
Vizagapatam	110.79	110.79	96.87	98.54	95.16	107.12	90.72	91.16

TABLE 11

Quintile Averages and Inter-Quintile Differences of Annual Precipitation (expressed as % of the mean)

Station	1871—1900	1901—1930	1931—1050	2—1	3—2	3—1
	1	2	3			
Aden	2.33	1.67	0.67	—0.66	—1.00	—1.33
Akyab	187.50	222.50	184.20	+35.00	—38.30	—20.80
Alexandria	9.25	7.36	5.96	—1.89	—1.40	—2.34
Allahabad	39.75	37.92	38·63	—1.83	+0.71	—0.21
Baghdad	7.82	5.95	7.64	—1.87	+1.69	+0.75
Bangkok	—	54.60	56.37	—	+1.77	+1.77
Banglore	34.32	35.16	34.39	+0.84	—0.77	—0.35
Basra	—	7.19	7.92	—	+0.73	+0.73
Beirut	36.65	35.08	33.27	—1.57	—1.81	—2.59
Bombay	73.39	67.66	76.19	—5.73	+8.53	—5.67
Bushire	12.74	10.00	10.10	—2.74	+0.10	—1.27
Calcutta	63.46	63.84	63.38	+0.38	—0.46	+0.27
Cochin	115.90	117.91	119.87	+2.01	+1.98	+2 97
Colombo	85.84	80.26	92.51	—5.58	+12·25	+9.46
Delhi	27.91	24.58	28.05	—3.33	+3.47	+1.81
Hongkong	87.01	85.80	87.01	—1.21	+1·21	+0.61
Ispahan	3.34	4.88	4.33	+1.54	—0.55	+0.22
Jaipur	25.57	22.80	23.87	—2.77	+1.07	—0.31
Jakarta	72.93	71.69	71.40	—1.24	—0.29	—0.91
Jask	3.99	4.66	4.55	+0.67	—0.67	+0.23
Jerusalem	27.57	22.91	20.65	—4.66	—2.26	—4.59
Karachi	7.46	7.46	8.05	+0.09	+0.59	—p.59
Krasnovodsk	4.34	4.32	2.86	—0.02	—1.46	—1.47
Kuta Draja	68.74	62.23	67.68	—6.51	+5.45	—2.19
Lahore	20.43	17.59	17.31	—2.84	—0.28	—1.70
Leh	3.12	3.29	3.55	+0.17	+0.26	+0.35
Madras	50.11	52.11	44.03	+2.00	—8.08	—7.02
Mandalay	34.77	36.90	34.90	+2.13	—2.00	—0.94
Muscat	5.12	3.71	2.94	—1.41	—0.77	—1.48
Mergui	165.37	163.42	158.90	—1.95	—4.52	—5·49
Meshed	8.00	10.01	10.68	+2.01	+0.67	+1.68
Nagpur	48.16	46.91	51.72	—1.25	+4.81	+4.18
Peshawar	15.58	13.96	12.04	—1.62	—1.92	—2.73
Port Blair	113.51	115.97	122.00	—2.46	+6.03	+7.26
Pnom Penh	—	56.25	51.40	—	—5.45	—5.45
Port Victoria	100.30	95.59	94.96	—4.71	—0.63	—2.95
Quetta	10.50	8.39	8.94	—2.11	+0.55	—0.50
Rangoon	99.53	106.58	110.75	+7.05	+4.17	+7.70
Shillong	82.27	82.57	90.60	+0.34	+8.03	+8.20
Singapore	85.63	96.42	81.04	+10.79	—15.38	—9.98
Tashkent	13.78	14.25	15.43	+0.47	+1.18	+1.42
Tbilisi	19.61	19.63	21.70	+0·02	+2.13	+2.14
Tehran	8.86	9.35	8.82	+0·49	—0.53	—0.28
Trincomalee	64.55	64.06	69.12	—0.49	+5.06	+4.82
Vizagapatam	41.44	38.82	35.20	—2.62	—3.62	—4.93

MAP 21


R 1901/30 – R 1871/1900
(expressed as % of x̄)
R 1931/50 – R 1901/30
R 1931/50 – R 1871-1930

of the Indian Ocean. During the following decade, the rainfall decreased over Egypt, Saudi Arabia, Iran, S.E. Asia and Northern and Eastern parts of the Indo-Pakistan sub-continent. A major decrease was also observed over Turkomnistan S.S.R. The rest of the region under study recorded an increase of rainfall.

Map 21 shows the inter-quintile differences of precipitation. It may be seen that the quintad 1901-30 recorded an increase of rainfall over that of the previous decade in Iran, Central Tibet, Burma and Central China. The Madras coast, the eastern coast of Viet Nam, Malaya and Sumatra also showed a similar increase. A remarkable decrease of rainfall occurred over the Levant, Saudi Arabia, Iraq and the Indian ocean. With the exception of Baluchistan and some parts of Southern Bharat the Indo-Pakistan sub-continent also witnessed a fall of precipitation.

During the period 1931-50, the negative trends over S.E. Asia, China, Bharat, Iran and the Indian ocean changed to those of positive. The only places which did not observe this reversal of trend were the Middle East excluding Iran and the Central Asiatic Soviet Republics. The rainfall continued to decrease over the Middle East and increase over Central Asia.

A confirmation of the trends given here may be found in the more elaborate statistical studies of Bose (25) Satakopan (26) Carruthers (27) Ananthapadmanabharao (28) Pramanik, Hariharan and Ghose (29), Pramanik and Jagannathan (10) and Kraus (9) for Bharat and those of Mubashir (30) for West Pakistan. The persistent decrease of rainfall over the Middle East is reported in the studies of Butzer (34) and Murray (35). Indirect evidences of continued desiccation in this region may be found in the works of Stebbing (36) Ball (37), Hellstrom (38) and Sandford (39). The pluviometric changes in the drainage basin of the Caspian Sea have been extensively dealt by Bruckner (41) Berg (42) Wagner (43) Zaikov (44) Apollov (45) and Tashkin (46).

In conclusion it may be said that whereas the rainfall conditions have been improving over the S.W. monsoon regime during the recent years they have shown deterioration over the N. E. monsoon regime. The rainfall has been persistently decreasing over the Middle East and increasing over the Soviet Republics of Central Asia. The trend seems to be most probably connected with a northerly shift of the tracks of western disturbances. The deterioration of rainfall in the arid and semi-arid zones of West Pakistan and Bharat may also be due to a reduction in the winter quota of the annual precipitation.

In the end, the writer wishes to call attention to the fact that the region dealt herein has the best-developed monsoon system in the world. The apparent complexity of the variation-patterns is largely attributable to the violent seasonal and regional contracts which form the very crux of this colossal phenomenon.

Many such and other obscure relationships will readily submit to exposition if the annual parameters are resolved into their seasonal components and studied separately.

6. Summary

An examination of the decennial and inter-quintile variations reveals the following trends in the major climatic elements.

1. The rising trend in the atmospheric pressure in the S. Asian L.P. and the Equatorial Trough which was observed since 1871 terminated during the period 1905--15 and was replaced by a negative trend which continued upto 1950. An increasing trend after this period has appeared at many places. The trends in Siberia and its regime have been opposite to those prevailing in the two regions mentioned above.

2. The decreasing trend of temperature over South and Central Asia which ensued after 1870 was completely replaced by a rising trend in 1920 which lasted at least upto 1950. The Indian Ocean has been behaving in an opposite direction.

3. The rainfall continued to increase over the regime of the N.E. monsoon and decrease over that of the S.W. monsoon since the beginning of the period upto 1920 when a reversal of the trend took place. The rainfall has been persistently decreasing over the Middle East (excluding Iraq and Iran) and the arid and semi-arid zones of West Pakistan and Bharat and persistently increasing over the Soviet Republics of Central Asia.

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EVOLUTION OF DRAINAGE IN THE INDUS PLAIN

By

Kazi S. Ahmad & Anis A. Abbasi.

The study of the evolution of drainage of the Indus Plain is an interesting problem of physical geography. There have been notable changes in the drainage since late Tertiary upto the present. Researches in the stratigraphy of the Himalayan submontane region and the study of physiography have helped to a substantial extent in the elucidation of the hydrography of this area.

The physical history of the Indus plain is the history of its wandering rivers which have shifted their courses from age to age and in some parts even year to year. The whole plain is seamed literally with abandoned river channels. These can be traced for hundreds of miles in some parts partly silted up, and in other completely levelled up by the work of wind, water and biological agents. These processes in the drainage of the area are still in progress, the rivers are constantly shifting their courses, cutting one bank and silting on the other, raising their beds overflowing the levees and flooding thousands of sq. miles every year.

The earliest hypothesises regarding the origin of the drainage in the Indus Plain date back to late 19th century when the geologists and the zoologists tried to show on faunistic grounds that there was some relationship between the Indus and the Ganges river systems. The first suggestion regarding the drainage of N. India came from Murray (20) in 1866 in which he considered that "the plain of upper India was once an arm of the sea, that it was cut off by the rise of the coast in Sind and Kutch, and gradually converted into a brackish and then a fresh water lake, discharging itself by the Ganges and that in the meantime the marine dolphin inhabiting the sea had gradually become platanistae." He then supposed that the Ganges was cut off from the lake, which overflowed again, and this time into the Arabian Sea, the dolpins of the Indus and the Ganges being specialized during the change. Murray's hypothesis lacked geological support. There is no evidence to show that there was sea on the site of the Indo-Gangetic plains. On the contrary, there are facts which run counter to his views. Recently some of the deep test holes done in the alluvium of the Indus plain and the lithological studies of the sediments have confirmed beyond any boubt that there were no marine conditions in the plains within the recent geological times. Researches on the physiography of Indus plain have shown that there is no well marked water-shed between the drainage of the two river systems. The land lying between the Jumna and Sutlej is seamed with abandoned river channels and there are evidences (15) which indicate that once the Jumna flowed into the Arabian Sea. It was prehaps during the reversal (35) in the flow of the Ganges and the Jumna together with their tributaries to the bay of Bengal that the animals may have migrated from one river to the other.

The idea of a single westwardly flowing river and its dismemberment into the two drainage systems came from R.D. Oldham (26) in a paper read by him at the Royal Geographical Society in December, 1893, in which he discussed that "at first the drainage of this depression had but one outlet, where the Indus now reaches the sea, and in this great river formed by the whole of the drainage of the Himalayas a certain species of dolplin established itself, and gradually acquired the habit of living and pursuing its prey in fresh water. At a later period a depression was formed between the Rajmahal and Asam hills, by which a gradually increasing portion of the drainage escaped and the single river broke up into two separate drainage systems, one finding its way to sea by the Indus and the other by the delta of the Ganges, and Brahamaputra (1)" Further, Oldham adds in his manual (25) that "the indications of the sea having existed up the Indus Valley within the recent period and the absence of any similar conditions in the delta of the Ganges make it probable that the former was the original outlet of the drainage and that the formation of the gap between Rajmahal and Gharo hills and of Gangetic delta, is geologically of recent date." It may, however, not be correct to reconstruct the past drainage history of the plains simply on the faunistic basis. Many geologists and naturalists (1, 2, 3) have proved that these views are not enough to support such hypothesis.

The advancement of knowledge of the tertiary formations and specially about the Siwaliks further support the concept of the single drainage system for the Indo-Gangetic plain.

The Siwaliks* are found from Assam to Kashmir along the foot hills of the Himalayas and then extend southwards along the western hilly region upto Karachi. The Siwaliks are detrital rock deposits brought by very swift flowing rivers and deposited at the foot of the Himalayas. They range from middle miocene to lower pleistocene in age and mostly comprise conglomerates, clays and coarsely bedded sandstone ranging in thickness from 15,000 to 17,000 feet, showing a marked lithologic uniformity throughout. The lithological study of the Siwaliks shows a great similarity with the present alluvial deposits of rivers, the only difference being that the Siwaliks have been compacted due to folding and faulting movements.

*The term Siwalik is due to H. B. Medllicott, who applied it to the rocks at the foot of the Himalayas between the river Ravi and the Ganges. The term was used by A. A. Wynne for the Potwar rocks and was further applied to Manchers by Blanford and H. E. Pilgrim.

(a) M. G. S. I pp2—pp. 3, 1869 (b) M. G. S. XVII, P.57, 1879, 165, 160 (1883)

(c) R. G. S. I XXVII p. 163, 1908, XL I. 179 (1910 VI II.)

In 1919, two eminent geologists, Pascoe (27) and Pilgrim (28) who had extensive knowledge of the tertiary geology at that time published two papers independently in which they proposed that the Siwaliks were deposited by a large river (MAP I) which had its origin in the N. E. corner of Assam, and flowed to Kashmir, in a course where the Siwaliks exist and then to the Arabian sea slightly to the west of the present Indus. Pascoe called it the "Indo-Braham" and Pilgrim "the Siwalik".

Sir, Edwin Pascoe's (27) view regarding the early history of Indus is that:—

(i) "In Eocene times a gulf extended from Sind northwards as for as Afghanistan and then curved eastward and south eastward through Kohat and the Punjab to the neighbourhood of Nanital".

(ii) "This gulf gave place to a great river, the head waters of which constituted the portion of the Brahamaputra now flowing inAssam. This river flowed westward and northwestward along the foot of the Himalayas as far as N. W. Punjab, where it turned southwards along a line not very different from modern Indus, and emptied itself into the Arabian Sea. In other words, the Assam Brahamaputra was once the headwaters of the Indus".

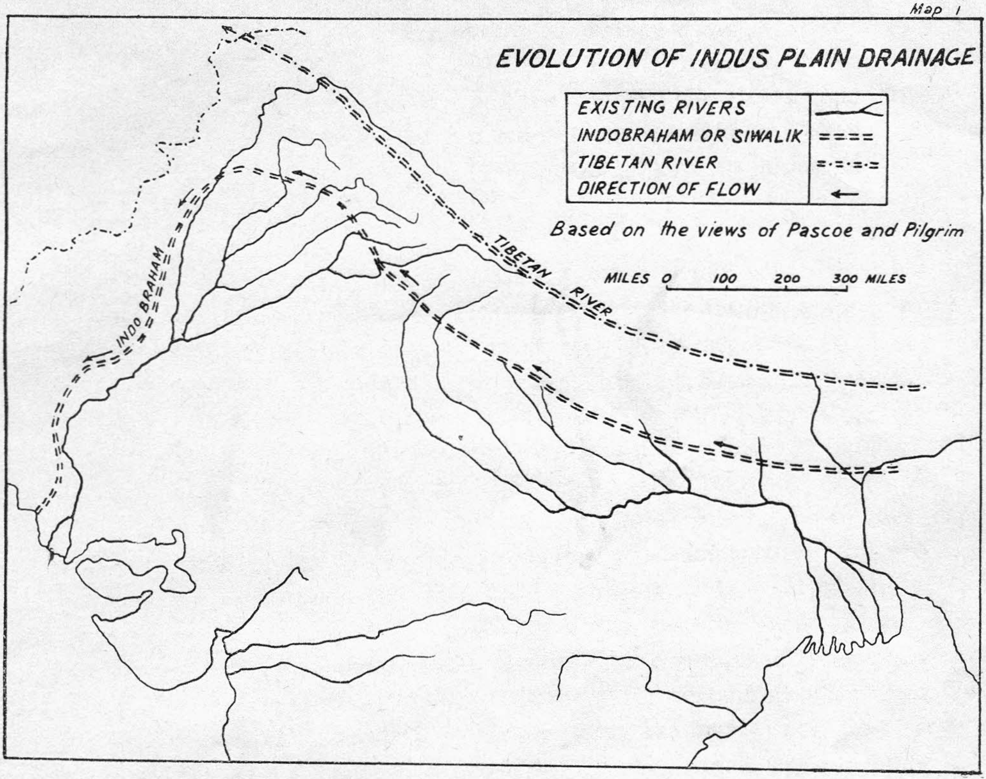
(iii) "Two separate rivers or two branches of the same river debouching into the Bay of Bengal, cut back and beheaded this old Indus, the eastern capturing the Assam portion to form the Brahamaputra and the western capturing gradually piece by piece the portion that intervenes between Assam and the present Jumna".

(iv) "In the meantime this old river was being still further reduced by the piece meal capture of the portion lying between the Jumna and the Jhelum by its own tributaries, the Jhelum, the Chenab, the Ravi, the Beas, the Sutlej and the Ghaggar".

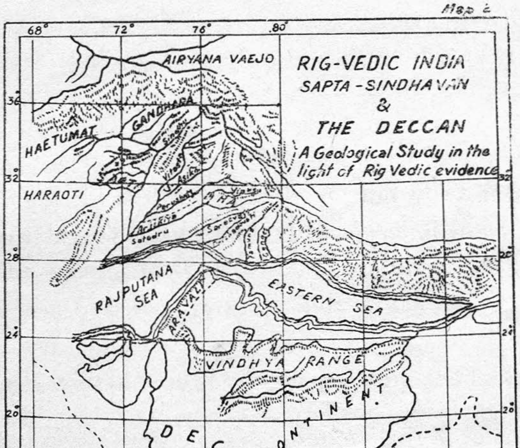
(v) "That the Attock part of the present Indus was a tributary of this old river which at a comparatively early period cut its way back into the Kashmir, where it captured the upper waters of a large river that flowed N. Westwards, and either found its way into the Oxus or curved southwestwards into eastern Afghanistan".

Pascoe had worked extensively on the petroleum geology of N. W. Punjab. While explaining the silting process and the mode of deposition of coal, oil and gypsum of that region, he came to the conclusion that they were laid down in a marine gulf and that "such a filled-up gulf is naturally followed by a river". He quotes the example of Burma and Mesopotamia gulf in support. Regarding the Siwaliks, he seems to have been much impressed by their great thickness averaging over 16,000 feet extending in a belt from Assam to Soan Valley and thence to the neighbourhood of the outlet of the Indus.

Map 1



Map 2



Ref. – Rig-vedic India
Calcutta University

He thinks that "it seems more reasonable to deduce a single river rather than a number of transverse streams." According to his hypothesis the river carried the drainage of Northern Gondwanaland and the southern Himalayas, and flowed Northwest-ward. Pilgrim's suggestion of the Himalayan rivers having N. W. pointing "Vs" across the Siwalik/Alluvium boundary further strengthens his argument of a former N. W. flow of the Siwalik river.

DeTerra (8) and Krishnan (14) lead the other school which does not believe in the existence of the Indo-Braham. DeTerra regards the siwalik sediments as "Local precipitates of an antecedent drainage" and supports his argument from the examples of better explored foreland troughs north of the Alps and Rocky mountains. Regarding the westward flow of the "Indo-Braham" he writes, "to us it appears the other way round". Further he refutes the faunistic evidence and believes in intercoastal migration of fauna under "similar climatic" conditions. The occurence of N. W. pointing "Vs" which according to Pascoe are "the remnant of a right bank tributary is however a mystery for DeTerra, and he frankly admits that he is unable to put forward any argument against it. Krishnan (I4), however comments that, movements of appreciable magnitude have taken place especially in the eastern parts of the Himalayas in post-Siwalik times and these would certainly have produced great changes in the courses of the rivers which existed at the time of the deposition of the Siwaliks" He further asserts that "the statement by Pascoe gives the impression that most of the streams have the above mentioned V-shaped course, which generalization does not appear to be true. The present courses of these rivers may have little in common with previous drainage lines and can, therefore, not be traced to pre-Siwalik times. In any case the rivers should naturally be expected to cut accross the Siwalik strata partly along and partly accross the trend of the ranges i.e. in a general westerly or S. westerly direction in the western Himalayas. The drainage will be dependent upon the structural features of the mountain terrain which it traverses and on merging from the Siwalik will take the directions of the general slope of the plains. Hence it would appear that the present features cannot be taken as lending support that these were the tributaries of a westward flowing Indo-Braham."

The views of DeTerra and Krishnan are commendable, for several reasons.

(1) It is now known beyond any doubt that Siwaliks extend underneath the Indus and the Ganges plains for several miles. Recently in two test holes in the neighbourhood of Lyallpur, the Siwaliks were encountered at a depth of about 540 feet (13). Therefore the existence of the Siwalik formation along the Himalayan foot hills is not necessarily indicative of a river bed.

(2) The study of Siwaliks does not allow us to assume that they were deposited in the flood plains of a mighty river. There is no other example of such a gigantic longi-

tudinal submontane river anywhere else. Most probably the Siwaliks were deposited in large fresh water lakes, which were inter-connected with each other and had their outlet to the sea.

(3) The study of the Himalayan orogeny clearly shows that the Rajmahal gap came into being in the middle Miocene times, therefore, the Siwalik river, if at all it existed must have found its way to Bay of Bengal through that gap instead of loitering all the way north-westward.

(4) Another intresting fact is the discovery of Dr. C. S. Fox (9) of estuarine conditions in the supposed place of origin of Siwailk river at that period.

(5) The faunistic evidence, as Prasad (29) pointed out does not lend enough support as far as the existence of Siwalik or Indo-braham river is concerned.

To us it appears that the debouchers of the Himalayan rivers during the Siwalik times were where they are at present. The Sutlej, Ravi, Chenab, and Jhelum after passing through the Siwalik range, and the Indus through salt range brought abundant sediments which they deposited in the Indo-Gangetic trough. The filling in of the trough took a few million years. During the early period of the filling of the trough the concealed extension of the peninsular block (whose extension has been shown by Glennie and confirmed by test drilling by WAPDA) acted as barrier in the flow of the rivers. Next step was the cutting of the burried ridge by the rivers, which found their way through and above it. After crossing the barrier the rivers started depositing alluvium further to the south and entered into the Arabian Sea through the gulf of Cutch and the gulf of Cambay which at that time were larger and extended much further north.

Throughout the period when the Indo-gangetic alluvium was being deposited the rivers had rambling courses and were shifting their channels very frequently. The most important change (15,35) that took place was the reversal of flow of the Ganges and the Jumna to the Bay of Bengal. Due to this change there was considerable depletion of the water of the Indus basin. On the other hand the gradual shifting to the west of the Punjab rivers further reduced the water supply of the eastern section of the Indus valley causing the formation of the Great Indian desert which was once being. watered by both the Ganges and the tributaries of the Indus.

Some evidences of old courses of rivers is contained in historical literature in association with the location of town and routes followed. But there are few maps available. No authentic maps were published before the later part of the 18th century. The geology of the entire Indus plain is not known fully. Some geological work done on the Doabs and the landforms and soil maps provide a valuable data. However, by carefully collating the work of different authors and studying the details of the phsyiographic conditions from aerial photographs, air mosaics, and landform maps, approximate courses can be determined.

The most ancient record having some geographical bearing on the Indus plain is found in the Rigvedas. Rigveda is a sacred book of Indo-Aryans consisting of 1028 hymns in the praise of different Gods. These hymns were composed by the holy Gods when the ancient Aryan civilization flourished in the Indus plain. Wheeler (36) regards the age of Rigvedic poetry of Indo-Aryans to 12th Century B. C. or earlier.

Dass in the light of Rigvedic evidence has tried to reconstruct the geography of the sub-continent of the time when the Rigvedic hymns were composed. He has tried to show on his map (MAP No. 2) that there were two seas in the Indo-gangetic plain one he calls the Rajputana Sea, covering the Rajputana desert and the other the Eastern Sea covering the Gangetic plain. From his map it also appears that the two seas were joined together..

There is no indication whatsoever of sea having existed in the Indo-Gangetic plains in such a recent period as shown in his map. It appears that since he found on the present topographical maps Saraswati loosing itself into the deserts, and the Rigveda (VII. 95.2) mentions that Saraswati flows from mountains to the sea, he concluded that there must have been a sea where we find the present Rajputana desert. It can safely be said that Dass's interpretation of Rigvedas in the reconstruction of the geography of this area is merely conjectural.

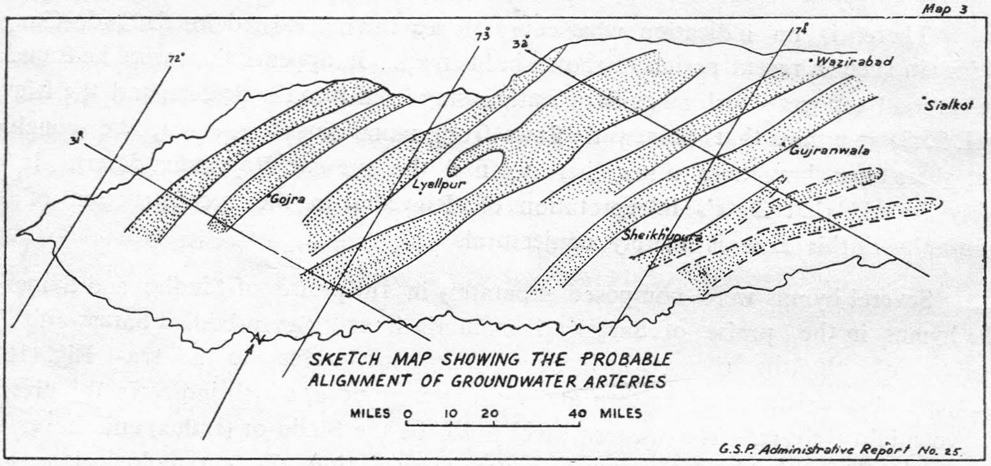
Several hymns were composed separately in the praise of Sindhu and Saraswati. The hymns in the praise of Saraswati maintain it as "Seven-bodied Saraswati" The greatest of all the rivers which flows from mountains to the sea- Rig. (163,5) mentions the existence of eastern and western Samundra, which indicates the presence of two mighty rivers. The western river must be the Sindu or (Indus) and the eastern Saraswati. There is, however, much confusion regarding the entymological sense of the word Samundra. Macdonell (17) considers that "the Indo-Aryans were not directly familiar with the ocean, it is therefore clear that they regarded the collection of water on large scale as ocean". Further, Hopkins (12) is of the view that "some scholars believe that these people had already heard of the two oceans (i.e. Bay of Bengal and the Arabian Sea) which is again doubtful in extreme. No descriptions imply a knowledge of oceans, and for them the ocean means merely a 'confluence', in general a great ocean body like air, as Indus is too wide to be seen across, the name may apply in most cases to the river".

From the study of Rigvedic hymns and the physiography it appears to us that in Rigvedic times, the Jhelum, the Chenab, the Ravi, the Sutlej and the Beas flowed in a slightly south-easterly direction towards Bahawalpur where they were joined by

Hakra and Jumna. The combined stream must be the Saraswati of the Indo-Aryans, which flowed independently without joining Indus into the Rann of Kutch which was an inland Sea at that time. A lot of work has been done by the Ground Water Development Organisation now called WASID. In order to study the exact nature of the alluvium, this Department drilled thousands of holes in the upper Indus-plain, complete profiles of the alluvium have been plotted, and the porosity and permeability of the sediments have been determined. Utilizing this data Kazmi (13) prepared a map (No. 3) showing the probable alignment of ground water arteries in Rechna Doab. The dotted areas in his sketch map bear sediment with relatively higher permeability and having coarser grain size. Normally the abandoned river courses have coarser material than the adjacent area, Ground water thus naturally follows the ancient channels.

The map of Kazmi showing the trend of the underground drainage in the Rechna Doab indicates the fiow of ground water further to the south east. If this could apply to the sub-terranean drainage of the Punjab Plain then an inference could be drawn that the seven rivers must have flowed further to the east and may have joined together before falling into the Rann of Kutch.

Map 3



SKETCH MAP SHOWING THE PROBABLE ALIGNMENT OF GROUNDWATER ARTERIES

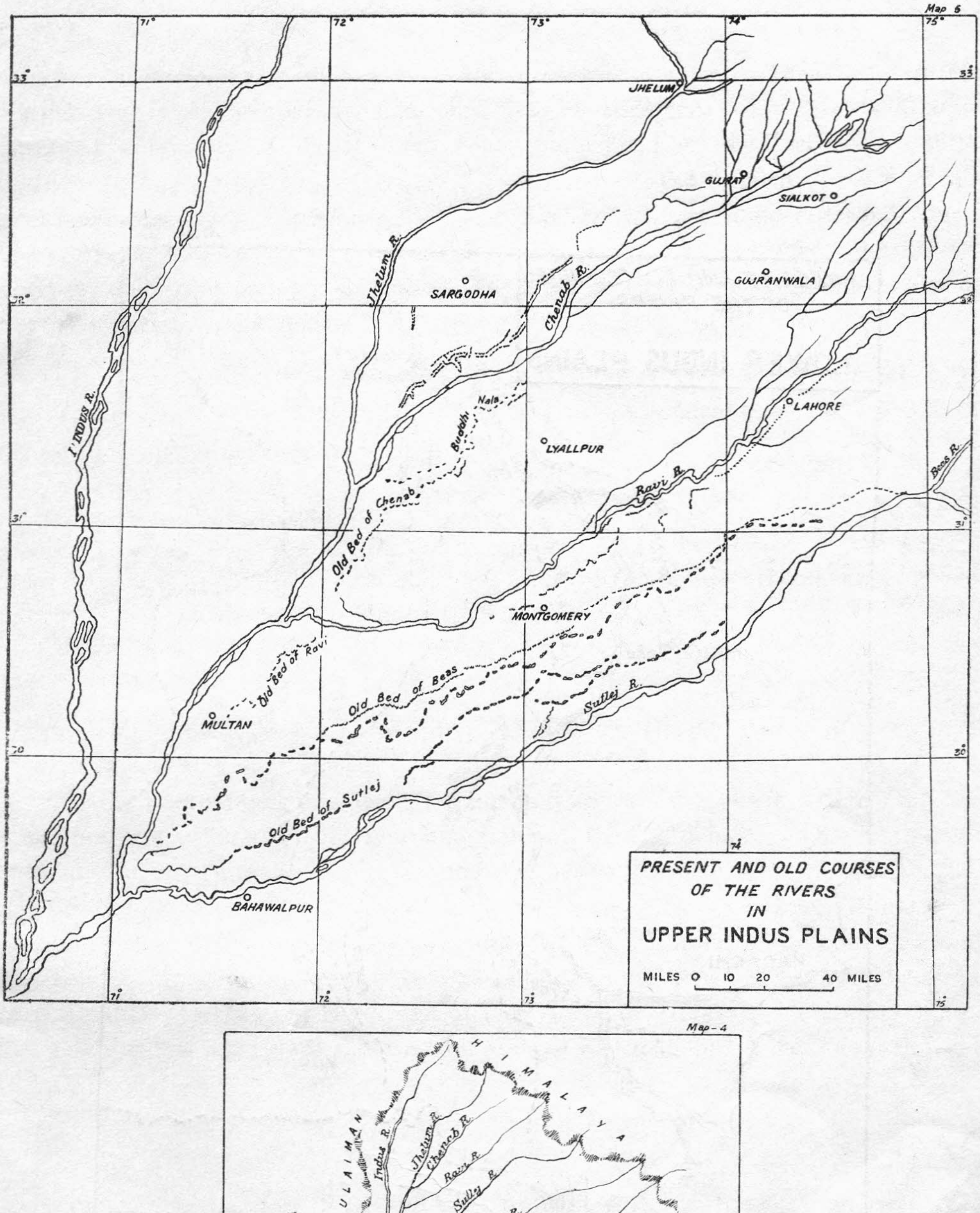
G.S.P. Administrative Report No. 25.

The changes in the courses of various rivers during the historic times may be determined from the locations in respect of towns as given in historical accounts, and from physiographic study based on large scale maps and aerial photographs. The old courses of the rivers of Indus Plains are shown in maps 5 and 6.

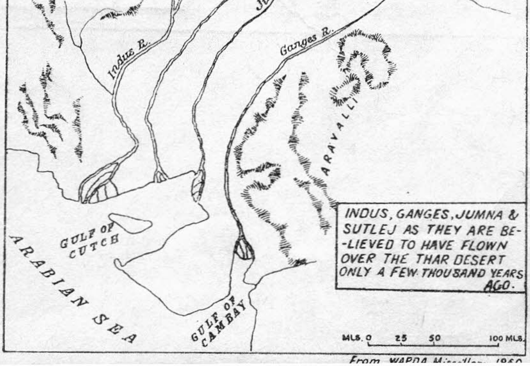
SUTLEJ

Amongst the rivers of the Panjab, the Sutlej seems to have adopted many different courses. Patiala and Ferozepur districts contain numerous abandoned river channels. There are many evidences which point that Sutlej after debouching from the hills in the neighbourhood of Rupar passed near the boundary of Patiala State and then passing through the south of Ferozepur district joined the ancient Hakra, somewhere in the neighbourhood of Fort Abbas. The ancient bed continues to the south, at

Map 5

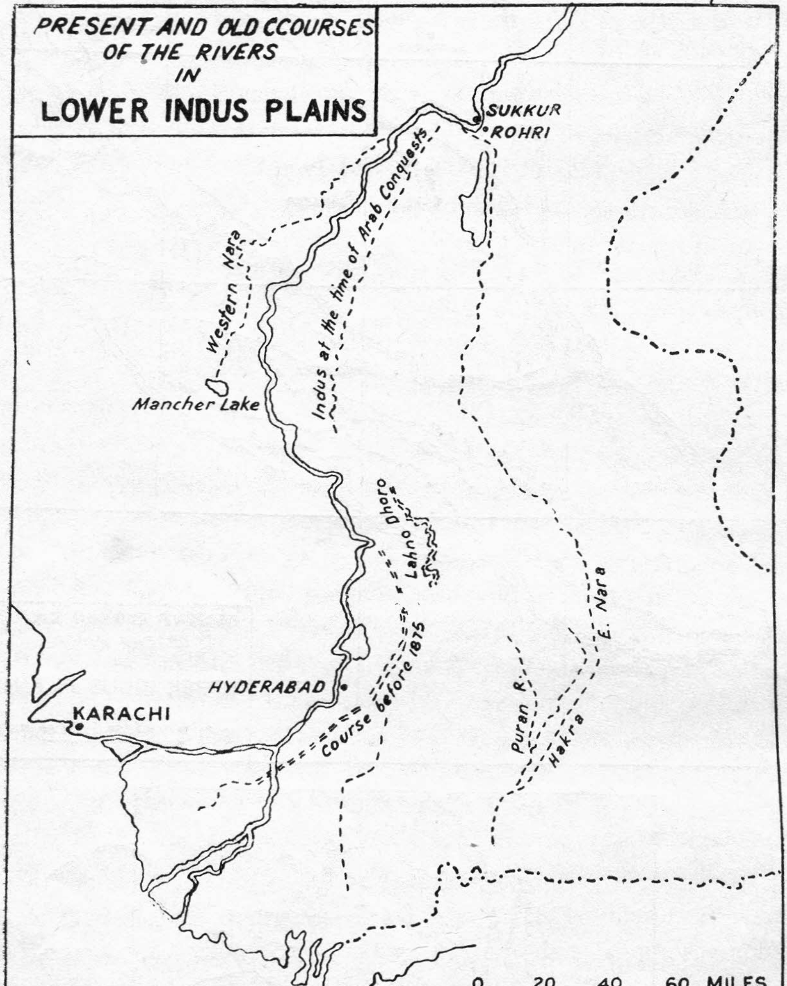


Map-4



From WAPDA Miscellany 1960

Map 6


PRESENT AND OLD CCOURSES
OF THE RIVERS
IN
LOWER INDUS PLAINS
SUKKUR
ROHRI
Indus at the time of Arab Conquests
Western Nara
Mancher Lake
Dhoro
Lahno
E. Nara
Puran R.
Hakra
HYDERABAD
Course before 1875
KARACHI
0 20 40 60 MILES

places it has been completely obliterated by the moving sand dunes. There are numerous depressions known under different names and are in alignment with this bed, which indicates the continuity of the channel. This channel can be traced with fair accuracy throughout Sind upto the Rann of Kutch. The study of the ancient history of this region shows that parts of Bahawalpur and Sind which are almost desolate due to scarcity of water and where we do not find anything except sand was once a fertile tract of country supporting a big population. The archaeological remains in this region are in support of the above statement.

In the existing literature ([10,21,22,23],) there is a great controversy on the lower course of this river. Some regard that it followed an independent course to the Rann of Kutch whereas others believe that it joined the Hakra.

Throughout the historical times, the river Sutlej has shown a marked westerning tendency. Towards the close of the 18th century, the river shifted to the west and captured Beas at Harike Pattan, both the rivers after abandoning their channels flowed into a new course which almost coincides with its present course.

BEAS

From the present confluence of Sutlej and Beas at Harike Pattan it is possible to trace the old channel of river Beas through Lahore, Montgomery and Multan districts. From the aerial photographs and land form maps it appears that it has well marked high bank on the right, where as there is no high bank on the left, which indicates that the changes in its course have not taken place further to the west of the right high bank. During the time of Timur the Beas was running in its course through Lahore, Montgomery, and Multan districts, and joined Ravi some where below Tulumba. The country around it was full of prosperous towns. It was running in the same bed during the times of Akbar. Rennals ([32]) Map of Hindustan of 1788 shows the stream flowing in its present form. Cunningham ([5]) regards the probable date of its abandoning the channel to be 1790 A.D.

RAVI

Today the junction of Ravi and Chenab takes place to the west of Sarai-Sidhu. From aerial photographs the right high bank of Ravi can be distinctly traced in a line running from about 26 miles westward of Lahore along the Rechna Doab upto Tulumba. From Tulumba down to Kabirwala and Multan the whole tract is full of abandoned river channels. The Ravi had many marked alterations in its course during historical times. According to Cunningham, (5) the confluence of Ravi and Chenab in the times of Alexander was at a short distance below the present town of Multan. The presence of Ravi near Multan is also borne out during the times of Mohammad Bin Qasim, Tamur and Aurangzeb. In those days the Ravi was the main river of Multan.

Still the eastern part of the city facing the ancient course of the river is known as Tarafe-Ravi. The old bed of Ravi from Tulumba to Shujabad can still be seen on aerial Photographs.

CHENAB AND JHELUM

There have been many changes in the courses of Jhelum and Chenab since the invasion of Alexander and onwards. During the times of Alexander the junction of Chenab and Jhelum took place somewhere south of Hundewali. The Jhelum at that time was not making a big loop as it does now to the west of Sargodha. It flowed in a slightly straight course from Rasool. Similarly the Chenab flowed straight from Quaidabad, and the two rivers joined to the south of Hundewali. The junction of the two streams seems to have shifted to various places to the south of Sargodha. In the times of Timur the confluence of the two streams took place somewhere near Shorkot. The two combined rivers flowed south more to the east of present course. At that time Multan was in Sind Sagar Doab. Ravi then flowed straight from Tulumba and joined these streams somewhere above Multan. Later it appears that the combined water of Jhelum and Chenab acquired a more westerly course and Ravi then joined the Chenab and Jhelum below Multan, thereby transferring Multan to Rechna Doab. The present Budhi Nullah is an old bed of river Chenab.

LOWER INDUS

The whole of the lower Indus plain is seamed with abandoned river channels. At one time or the other the Indus and the Mihran of Sind must have flowed through them. "As regards the ancient courses of the lower Indus infinite has been the speculation, the theorization, the desertation, the argument and the contradiction upon this much vaxed subject" (5.) In the historical past it appears that the five Punjab rivers have met at different places south of the Muzaffargarh district. From thence onwards the flow of the water have sometimes been confined to single channel and at times dividing into several channels. The river seems to have been shifting sometimes to the east and sometimes to the west. In Lower Indus plain, the Indus after passing through the limestones range near Rohri, flows in a slightly higher ground than the adjacent flood plains. Although dykes and embankments exist on both sides of lower Indus from Kashmore down to the sea, there has always been a danger that the Indus may break through its embankment and acquire a new course.

There are also some other interesting features in the hydrography of this area. At present Indus has cut its course through limestone ranges between Rohri and Sukkur, It is said that the Indus used to pass through another gap in the Limestone range four miles south east from its present passage. Cunningham suggests that about 9 centuries ago this gap used to be the main bed of the river. The probable date of abandoning its former bed is now regarded about AD 962.

Raverty (30) is of the view that at the time of Arab conquest the major river of Sind was Hakra or Mihran of Sind. There has been a great controversy on the subject of the "Lost river of the Indian desert". Some have maintained that the lost river of the Indian desert was no other than Hakra or Sutlej, others believe that it was Indus or Mihran of Sind. Haig writes, "whether this has been proved or not it is certain that the Hakra of Lower Sind was formerly a part of the course of an independent stream, the drying up of which has been clamateous not only in reducing thousands of sq. miles of once fertile land and inhabited country to waste and solitude, but also in forcing an additional body of water into the already overcharged channel of the Indus, thus enormously increasing the risk of desolating floods along the Lower course of that river."

In the year 1758 an important change took place in the course of lower Indus south of Hala. It broke its bank and shifted its course 12 to 15 miles to the west.

There have been lot of changes in the delta regions. "A vast deal of delta is of comparatively recent formation for the small district dependent on Badin was the most southerly part of Sind in Akbar Badshah's reign and now it is over 70 miles from the southern most part of the delta. It is supposed and with very good reasons that the greater part of the delta of Shahbandar district of the Sind, as present constituted and the southern part of the Jarak district likewise are comparatively recent formation". So great have been the shifting of channels of rivers within the delta region that it is very difficult to draw some inferences regarding the course at different historical periods.

CONCLUSIONS

1. Pilgrim, and Pascoe, believe that in Siwalik times a single westwardly flowing river the "Indo-Braham" carried the whole drainage of the Indo-Gangetic plains into the Arabian sea. Krishnan and DeTerra do not believe in the existence of such river. The authors have shown that the latter view is more probable.

2. The whole plain is seamed with abandoned river channels. The old river channels have been located with the help of historical literature and physiographic evidence based on large scale maps and aerial photographs.

3. A study of the beds of the rivers in successive periods reveals a marked westerning tendency of the rivers which is in accord with Ferrel's law.

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NEWS AND NOTES

1. *THE TWELFTH ALL PAKISTAN SCIENCE CONFERENCE*

The annual session of the Pakistan Science Conference was held at the University of Sind, Hyderabad from January 14 to 19, 1960. The meetings of the Geology, Geography and Anthropology Section were held at Liaqat Medical College, Jamshoro. Due to the inability of Dr. H. I. S. Thirlaway to act as the President of the Section, Dr. K. U. Kureishi was asked to take his place who delivered his Presidential Address on "Some Characteristics of urban population in West Pakistan".* Mr. M. M. Memon of the Department of Geography of the Sind University acted as the Secretary.

The following papers were presented:-

Author & Title of the Paper

1. S. H. A. Shah:
Structure of the Area Between Ziarat & Wani.

2. J. M. Master:
Possibilities of Water Development in West Pakistan.

3. M. M. Khan:
Functions, Organisation and Programme of the Geological Survey.

4. A. K. M. Nuruddin Ahmad:
A Root Method of Factorization of a Cubical Expression.

5. K. G. Mowla:
Clouds, Surface Gusty Winds and Turbulences Associated with Jet Streams Observed at Lahore.

6. Mohammad Shabbar:
Projectively flat Lorentz-Inveriant Pathspaces whose Path-equations are the geodesic in a Curved Einstein World.

7. S. J. Ahmad & A. Halim:
Total Atmospheric Ozone & Geomagnetic Activity.

8. N. A. Khan:
Mechanism of Lightning in a Thunderstorm.

9. K. M. Khan:
Some results of scrutiny of Sea temperatures recorded at different depths as a part of I. G. Y. Programme on board of the Navy Ship Zulfiquar during her voyages in February, June and July 1958 in the Arabian Sea and the Bay of Bengal.

10. Sibte Nabi Naqvi & Muhammad Rahmatullah:
A note on climatology of the new federal capital of Pakistan in Potwar plateau.

11. Sibte Nabi Naqvi & Naeem Ahmad Khan:
The cloud seeding trials in the Central Punjab during July-September, 1955-56 Part II.

12. Akhtar Husain Siddiqi:
A Geographical factor in the evolution of the boat types of the Lower Indus Basin.

13. Luther H. Gullic:
Agricultural Land Use in Puerto Rico.

14. F. H. Khan:
Peat deposit of East Pakistan.

15. Mubashir L. Khan:
Recent Climatic Fluctuation over South Asia and the Indian Ocean.

16. Mubashir L. Khan:
Periodicities in the Precipitation of West Pakistan.

17. Mubashir L. Khan:
On the Recent Pluviometric Deterioration in the Arid and Semi-arid Zones of West Pakistan.

18. Kazi S. Ahmad & Anis Ahmad Abbasi:
Evolution of Drainage in the Indus Plain.

19. Serajul Arephin:
Sericulture in Rajshahi.

2. *GENERAL SYMPOSIUM ON ARID ZONE PROBLEMS*

The Symposium was held in Unesco House, Paris, between 11 to 18 May, 1960 and was attended by 250 scientists from different scientific branches and disciplines. Mr. P. Piganiol, the

*The name of Dr. H. I. S. Thirlaway appearing against the President on the Abstracts published by the Conference should therefore be substituted for Dr. K. U. Kureishy.

Director-General of the Scientific Research, Government of France acted as the President of the Symposium. The first of the Documentary Films on Arid Lands made for Unesco by World Wide Pictures was exhibited along with numerous other documentary material and illustrations on arid-zone projects being undertaken in various countries.

The conference met in eleven working sessions and discussed 44 reports presented on different aspects of the arid zone research. The major objective of these discussions was to review the present state of knowledge in different branches of sciences connected with the arid zone research, particularly after 1956. It may be recalled that the Unesco Arid Zone programme which was launched in 1951 became a major project in 1956.

The programme of the Conference was as follows:—

Part I—*State of the Scientific Knowledge*:

Five sessions were held. The subjects for discussion were surface water geology, geomorphology, hydrometeorology, microclimatology, salinity, ecology and physiology and energy from wind and local fuels in the arid zones.

Part II—*Action Undertaken*

The subject was discussed in two sessions. National Reports on Arid zone activities sent by the Governments of Iraq, Pakistan, Bharat, Morocco, Iran, U. A. R. & Sudan were distributed for information. Similar reports were submitted by I. G. U., I. U. G. G., C. C. T. A., International Commission on Irrigation & Drainage and International Commission for Conservation of Nature & Natural Resources. The United Nations organizations presenting reports on this subject included F. A. O., W. H. O., W. R. D., and Unesco.

Part—III Socio-Economic Problems of Development.

Three sessions were held under this category. The subjects for discussion included nomadism, utilization of water resources and problems of public response and education in connection with arid-zone projects.

Part IV.—*Future of arid-zone research.*

The subject was discussed in one session. All delegates participating in the Conference greatly appreciated the work done under the Unesco project and expressed strong desire to continue their efforts in the study of Arid Zones.

Delegates from Pakistan included Dr. S. N. Naqvi who acted as the Chairman of the Section on Climatology and hydrometeorology and Dr. Abdul Hafiz who performed as the Secretary to the Section of Arid Zone Soils and salinity. A paper by Dr. A. G. Asghar was also presented by the latter.

MUBASHIR L. KHAN.

3. *PROVINCIAL ADMINISTRATION COMMISSION REPORT*

The Presidential Cabinet and a Special Committee of Cabinet Ministers appointed by the President in February 1959 gave their final report on Provincial Administration. The major objective of the Commission was to suggest measures to create homogeneity in the executive machinery of the two wings of the country. It was also to advise the Government on matters of administration and increasing the efficiency of the machinery.

According to new arrangements the speed of development schemes will be immensely accelerated because most of the work will be given in the hands of the Divisional and Provincial councils. It will open a new era of co-operation between the masses and the Government. It will also enable the various councils to receive complaints of public and deal with them promptly.

The following suggestions have been made with regard to the administrative set up of the country. These have been accepted by the Government of Pakistan.

EAST PAKISTAN

Mymensingh District

It is suggested by the Commission that this previous district should be divided now into 3 districts. (a) Newly created Thana of Gouripur should form part of the Saddar sub-division of the proposed Nasirabad District. (b) Sub-division of Manikganj should continue to be part of the Dacca Division. (c) The district head-quarter may be located at Kishoreganj before the permanent headquarter of the proposed district of Quaidabad.

II *Bakarganj District*:

This district should be divided into two districts as follows:

(*a*) Barisal District.

(*b*) Patuakhali District.

III *Jessore District*:

Alfadange thana and the portion of Muhammad-Pur thana lying on the eastern side of the Madhu-mati river should be taken out of Jessore district and included in Faridpur district.

IV *Comilla District*:

Tippera district should be renamed as Comilla district.

V *Naokhali District*: The headquarter of the district of Noakhali should be shifted to Feni.

DIVISIONS:

The Province should be reconstituted into the following 4 divisions:

1. RAJSHAHI DIVISION: This division should consist of Rajshahi, Rangpur, Dinajpur, Bogra and Pabna districts.

2. KHULNA DIVISION: A new khulna Division should be formed comprising the districts of Kushtia, Jessore, Khulna and two new districts of Bakarganj and patuakhali.

The headquarter of this division should be at Khulna.

3. DACCA DIVISION. This should consists of the districts of Dacca, Faridpur and three dis-tricts to be taken out of the present district of Mymensingh.

4. CHITTAGONG DIVISION: This division should consist of the districts of Chittagong, Chittagong Hill Tracts, Noakhali ; Comilla and Sylhet.

WEST PAKISTAN:

DISTRICTS:

I. Multan District: This district should be divided into the following two districts:

(a) Multan district consisting of the four tehsils of Multan, Kabirwala, Shujabad, Khanewal, Mailsi and Lodhran.

(b) Vehari district consisting of the other three tehsils of Vehari Melsi and Lodhran, the headquarter of the new district should be located at Vehari.

II. Shahpur District : It should be renamed as Sargodha district.

III. Sheikhupura District : The six villages Shahdara, Kot Mohibu, Kot Begum, Nainsukh Saggian Kalan War ; and Shahdara Parao should be included in this district.

IV. Sibi and Jacobabad district : The sub-division of Nasirabad should be transferred to form a part of the district of Jacobabad.

V. Sukkur District: Machka Kanungo circle of tehsil Sadikabad consisting of Machka I and II, which form the enclaves of Rahimyarkhan dis-trict should be transferred to Sukkur district.

VI. Khairpur District : The tappas of Pir of Goth and Manghanwari, formerly the enclaves of Sukkur District should be included in Khairpur district.

Divisions:

West Pakistan should be divided into the following divisions :

1. PESHAWAR DIVISION (a) Hazara dis-trict and special areas under the charge of Deputy Commissioner, Hazara. (b) Mardan district. (c) Peshawar district and the special areas under the charge of Deputy Commissioner, Peshawar (d) Kohat district and special areas under the charge of Deputy Commissioner, Kohat.

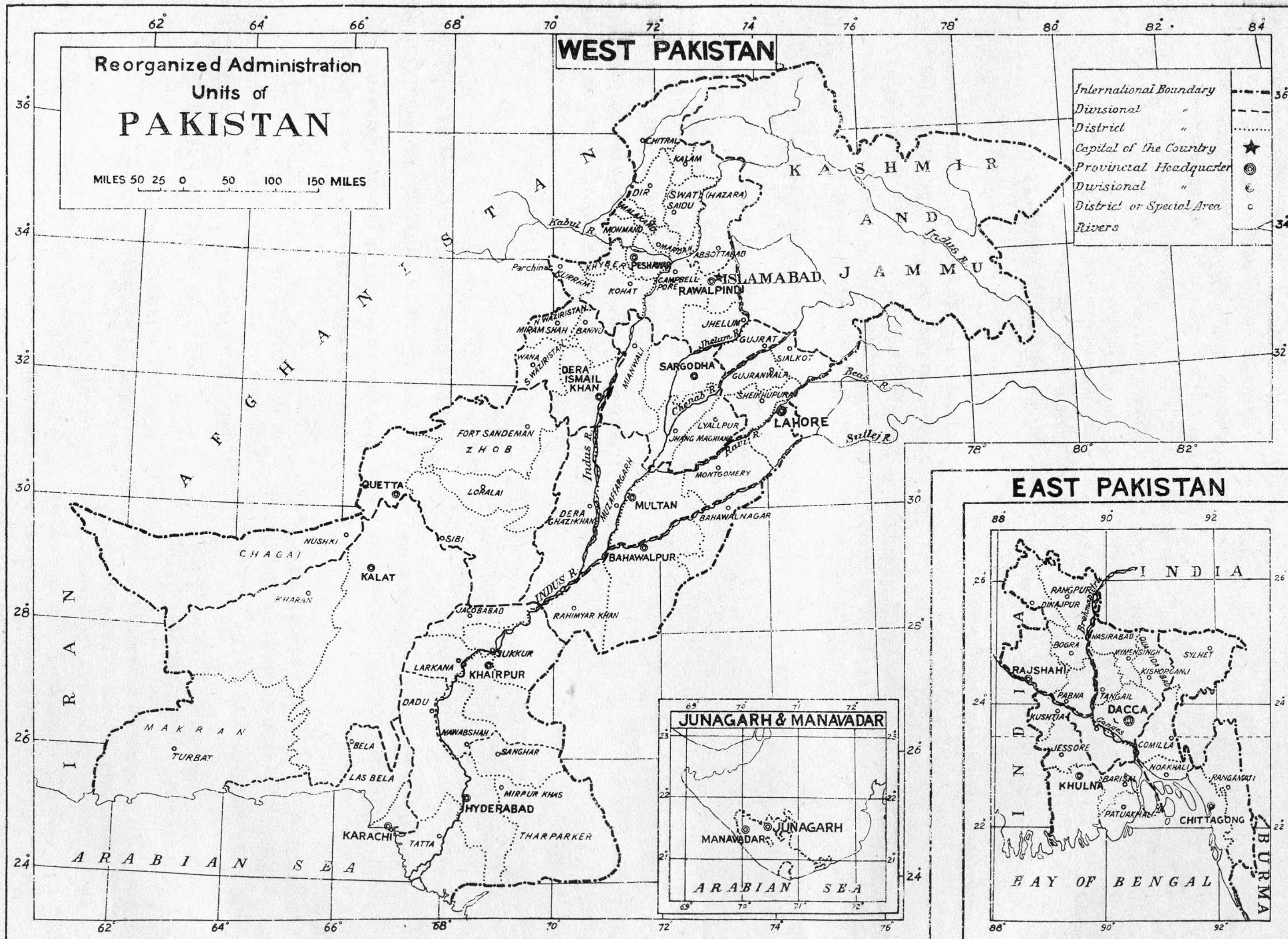
Baradar Khel, Latamber and Karak Police Station (f) Malakand Agency (g) Mohmand Agency (h) Khyber Agency (i) Kuram Agency.

2. DERA ISMAIL KHAN DIVISION (a) Dera Ismail Khan district and special areas under the charge of Deputy Commissioner, Dera Ismail Khan, plus shirani area of Zhob Agency.

(b) Bannu district and special areas under the charge of Deputy Commissioner, Bannu and Bahadar Khel, Latamber and Karak Police Stations of the existing Kohat District.

(c) North Waziristan Agency.

(d) South Waziristan Agency.


Reorganized Administration Units of PAKISTAN
MILES 50 25 0 50 100 150 MILES
WEST PAKISTAN
International Boundary
Divisional
District
Capital of the Country
Provincial Headquarter
Divisional
District or Special Area
Rivers
KASHMIR AND JAMMU
AFGHANISTAN
IRAN
ARABIAN SEA
CHITRAL
KALAM
DIR
SWAT
SAIDU
(HAZARA)
MOHMAND
MARDAN
ABBOTTABAD
PESHAWAR
KHYBER
KURRAM
Parchinar
KOHAT
CAMPBELLPORE
RAWALPINDI
ISLAMABAD
N. WAZIRISTAN
MIRAM SHAH
BANNU
S. WAZIRISTAN
WANA
DERA ISMAIL KHAN
MIANWALI
JHELUM
GUJRAT
SIALKOT
SARGODHA
GUJRANWALA
SHEIKHUPURA
LAHORE
LYALLPUR
JHANG MAGHIANA
MONTGOMERY
FORT SANDEMAN
ZHOB
LORALAI
QUETTA
MULTAN
MUZAFFARGARH
DERA GHAZI KHAN
BAHAWALNAGAR
BAHAWALPUR
SIBI
NUSHKI
CHAGAI
KALAT
KHARAN
JACOBABAD
RAHIMYAR KHAN
SUKKUR
LARKANA
KHAIRPUR
DADU
NAWABSHAH
SANGHAR
MAKRAN
TURBAT
BELA
LAS BELA
HYDERABAD
MIRPUR KHAS
THARPARKER
KARACHI
TATTA
Kabul R.
Indus R.
Jhelum R.
Chenab R.
Ravi R.
Beas R.
Sutlej R.
INDUS R.
JUNAGARH & MANAVADAR
JUNAGARH
MANAVADAR
ARABIAN SEA
EAST PAKISTAN
INDIA
RANGPUR
DINAJPUR
Brahmaputra
NASIRABAD
BOGRA
MYMENSINGH
SYLHET
KISHORGANJ
RAJSHAHI
PABNA
TANGAIL
DACCA
KUSHTIA
Ganges
JESSORE
COMILLA
NOAKHALI
KHULNA
BARISAL
RANGAMATI
PATUAKHALI
CHITTAGONG
BURMA
BAY OF BENGAL

These changes have been brought in Peshawar and Dera Ismail Khan especially for the furture prosperity of tribal men. This progressive work will be done without any interference in the internal administration of these areas.

3. RAWALPINDI DIVISION: (a) Campbellpur (h) Rawalpindi (c) Jhelum (d) Gujrat.

4. SARGODHA DIVISION: (a) Shahpur district (to be renamed as Sargodha district) (b) Mianwali district (c) Lyallpur district (d) Jhang district.

5. LAHORE DIVISION: (a) Sialkot, (b) Gujranwala, (c) Sheikhupura, (d) and Lahore districts.

6. MULTAN DIVISION : 1. Dera Ghazi Khan district (a) Muzaffargarh district (c) Montgomery district (d) Multan district (e) Vehari district.

7. BAHAWALPUR DIVISION : (a) Bahawalpur district (b) Bahawalnagar district (c) Rahimyar Khan district.

8. KHAIRPUR DIVISION: (a) Jacobabad district (b) Sukkur district (c) Larkana district (d) Nawabshah district (e), and district Khairpur Nasirabad sub-division of Sibi district of Quetta Division should be transferred to Jacobabad district.

The headquarter should be shifted from Khairpur to Sukkur.

9. HYDERABAD DIVISION: (a) Hyderabad district (b) Dadu district (c) Tharparkar district (e) Sanghar district (f) Thatta district except that an area of about 758 square miles comprising of 37 villages to go in Karachi Division.

10. KALAT DIVISION : (a) Kalat district (b) Makran district (c) Kharan district.

11. QUETTA DIVISION : (a) Quetta-Pishin (b) Sibi district (c) Loralai district (d) Zhob district (minus the Shervani area) (e) Chagai district.

12. KARACHI DIVISION : A new Karachi district comprising the present Federal area and 37 villages of Thatta between Dabeji and B and Murad (b) Lasbela district of Kalat Division.

Karachi should continue to be administered by the Central Government according to the Cabinet decision.

RASHIDA ATA.

4. *THE ATTOCK OIL COMPANY, RECENT TESTS & FINDING*

According to the hand-out released in the first quarter of 1959 the crude oil production from Khaur, Balkassar and Joya Mair oil fields amounted to 1988,189 Barrels. The discovery of oil at Karsal, some three miles from Balkassar oilfield constitutes an important land-mark in the history of the A. O. C. and its subsidiary Pakistan oilfields. The drilling at Karsal started in September 1957 and was carried to a record depth of 12751 feet. This beat the previous record held by B. O. C. at Lakhra (former Sind) which was 12660 feet. The well started production in commercial quantities in 1959.

The crude oil contains not only petroleum but it also contains natural gas which is released from the crudes when it comes to the surface. This Dhullian Gas is obtained under conditions very different from those at Sui. Dhullian gas unlike Sui Gas is not independent of oil. The inauguration of this Gas transmission scheme marks another milestone in the development of A. O. C.

The Company has not been content with the present production only. It is searching for more and more oil. During the past five years there have been introduced some important organisational changes for the purpose of prospecting oil. The Government of Pakist an has come to have 51.8% share in a Joint Corporation known as Pakistan Oilfields. In collaboration with other exploring firms the Attock Oil Company has been actively engaged in the exploration of oil at the following places :

I. Dhullian P. O. L. No. 1 The well has been carried to the depth of 9859 feet. Two small oil shows have been encountered in the Ranikot limestone. P. O. L. is now trying to produce oil in commercial quantities through acidization with the help of high pressure pump.

II. Karsal. Two oil wells have been declared successful and No. 3 well is being drilled. Oil is being produced in commercial quantities and the production of 1st quarter of 1959 exceeded 200 lbs.

III. Kallar Kahar. Drilling started on 20th May, 1957 and went over 6000 feet depth. It struck oil at 4000 feet depth but it was of very low pressure and the drilling was stopped. Another trial was made at Dhariala on a peak of the mountain. But large volume of water was met in the way. Government is considering to make the use of this water for chemical fertilizers.

IV. Chak Naurang. The work on this project was actively carried out during the year 1952-53. The well was drilled to one of the record depths, but the efforts were not crowned with success. Similarly Jhatla Test well (Near Talagang) disappointed P. O. L. It has costed Rs. 22 lacs.

V. Adhi Joint PPL/POL Test well No. 1 At the depth of 2098 feet very large volume of high pressure water broke and the work on the well was abandoned. It was decided then to drill a second well which was also abandoned. Same happened at Chakblikhan when P. O. L. Test well No. 1 reached 1056 feet depth, the well ran into high pressure water.

VI. Nandraki (Kohat district). Drilling was started in July 1956. The purpose is to discover what lies beneath the salt.

VII. Mahesian. It is Coy's first well where Diesel outfit has been erected. This equipment has cost Rs. 5,000,000. Drilling started in June, 1959 No result has so far been achieved.

HABIB KHAN.

5. *KOT DEJI EXCAVATIONS*

After 1920 some successful archaeological excavations have been made in the Indus valley sites of Harappa and Mohenjo-Daro. These works have provided considerable information on the material aspects of the Pre-Aryan Civilization. The recent excavations which have been in progress at Kot Deji since 1955 have stretched our knowledge of the ancient history of the Indus valley by another seven hundred years into the past *i.e.* from 2300 to 3000 B.C.

Kot Deji site is situated 15 miles south of Khairpur town and north of Deji fort on the highway to Hyderabad. The main axis of the site runs east to west and measures some 600 feet in length, the width is more than 400 feet and the height from the surrounding field level is about 40 feet.

Excavation work done in November 1955 and again in October to the end of December 1958 has proved that before the arrival of Harappa Mohenjo-Daro people, there flourished a well-settled and highly efficient community. The ruling classes of this nation lived in a fortified citadel which measures some 500 feet by 350 feet with a height of 40 feet. They lived in flat topped houses made of sun-dried bricks which indicate arid climate. Some large size ovens have been discovered which point to a regularized life and division of labour.

The most attractive structural feature of Kot Deji site is the Pre-Mohenjo Daro defensive wall of the citadel. Its length is 32 feet and width 20 feet. It was raised on bed-rock and built below with unchopped stone blocks and above with mud bricks. The inner habitation areas were quite near to this wall. But in the last stage of its history the wall suffered dilapidation.

Another important point leading to the investigation is the beautiful pottery of Kot Dijians. The work proves their skillfulness in this art. They have made pleasant designs and shapes, unknown to the pottery of Indo-Pakistan sub-continent. Some of the important forms are open-mouthed globular jars with short rim and flat base and straight walled and wide mouthed cylindrical vessels. Although there is a great difference in technique of both Mohenjo Daro and Kot Dijians, there are strong indications that the makers of the new types of pottery, were the forerunners of the Mohenjo Daro people in many respects.

The ruins prove that destruction of the Kot Deji Civilization was brought by floods and fire. It is probable that the fire was not caused by an accident but was the result of some great conflagration. Perhaps the new culture of Harappa and Mohenjodaro rose on the ashes of Kot Dijians around 2500 B. C.

RASHIDA ATA.

Statistical Supplement

TABLE I—AREA OF PRINCIPAL AGRICULTURAL CROPS IN WEST PAKISTAN

(in ,000 acres)

1947-48 to 1957-58

(Corrected upto 1. 12. 58)

Crops	1947-48	1948-49	1949-50	1250-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58
FOOD CROPS											
1. Rice	1957	2075	2305	2395	2181	2242	2513	2368	2397	2400	2709
2. Wheat	9771	10591	10336	10799	10144	9431	10426	10530	11187	11596	11708
3. Bajra	1998	2330	2368	2406	2018	2212	2584	2191	2203	2281	1877
4. Jowar	1053	1182	1362	1254	1090	1316	1513	1125	1325	1358	921
5. Maize	899	945	999	935	969	969	1062	1062	1061	1026	1079
6. Barley	414	573	497	430	434	482	518	450	774	455	572
7. Gram	9180	2796	2399	2757	2110	2033	2562	3045	3248	3150	3111
NON-FOOD CROPS											
8. Sugar-cane	466	483	543	470	475	627	721	750	709	780	980
9. Rape and Mustard	991	1049	908	1138	1365	1038	1078	1276	1456	1358	1410
10. Cotton	3049	2598	2744	3017	3318	3421	2870	3136	3486	3530	3592
11. Tobacco	29	38	41	51	54	42	61	110	78	71	88

TABLE II—PRODUCTION OF PRINCIPAL AGRICULTURAL CROPS IN WEST PAKISTAN

(in ,000 tons)

(1947-48 to 1957-58)

(Corrected up to 1-12-58

Crops	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58
FOOD CROPS											
1. Rice (1)	648	735	793	852	722	816	907	821	821	820	889
2. Wheat	3301	3974	3862	3930	2949	2366	3575	3136	3314	3582	3647
3. Bajra	296	394	371	385	262	267	462	347	341	362	281
4. Jowar	202	242	269	243	204	220	278	219	249	254	174
5. Maize	353	374	401	381	376	346	402	424	452	447	445
6. Barley	111	175	145	129	100	92	127	105	126	114	161
7. Gram	466	755	601	744	423	315	562	594	697	682	653
NON-FOOD CROPS											
8. Sugar-cane (2)	272	702	771	551	538	722	882	872	807	873	1082
9. Rape and Mustard	173	184	143	195	205	123	163	219	221	219	232
10. Cotton (3)	194	169	217	244	245	312	249	277	302	298	295
11. Tobacco	15	18	25	30	35	26	38	73	48	46	56

(1) Production in terms of husked rice (2) Production in terms of raw sugar (Gur) (3) Production in terms of lint cotton.

TABLE IV—PRODUCTION OF PRINCIPAL AGRICULTURAL CROPS IN EAST PAKISTAN

(in ,000 tons)

1947-48 to 1957-58

(Corrected upto 1-12-58)

CROPS	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58
FOOD CROPS											
1. Rice (1)	6736	7673	7378	7343	7034	7335	8245	7590	6384	8185	7598
2. Wheat	20	19	23	20	23	24	24	26	22	23	22
3. Bajra	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(a)
4. Jowar	(a)	(a)	(a)	(a)	(a)	(a)	(a)	(s)	(a)	(a)	(a)
5. Maize	2	2	3	3	2	2	2	2	2	2	2
6. Barley	15	16	17	15	16	17	16	18	18	16	12
7. Gram	51	49	52	47	52	53	54	63	43	3	35
NON FOOD CROPS											
8. Sugar-cane (2)	327	341	310	333	343	368	397	370	398	391	369
9. Rape & Mustard	78	83	86	89	100	103	100	105	104	93	67
10. Cotton (3)	2	3	3	3	3	3	3	3	3	2	3
11. Jute	1222	978	595	1073	1131	1218	645	833	999	985	1107
12. Tea	13	15	17	17	24	23	23	24	23	24	20
13. Tobacco	45	45	42	43	45	49	49	53	40	40	34

(1) Production in terms of husked rice (2) Production in terms of Raw Sugar (Gur) (3) Production in terms of lint cotton. (a) Below 500 tons. (b) Below 500 acres.

TABLE III--AREA OF PRINCIPAL ACRICULTURAL CROPS IN EAST PAKISTAN;

(in ,000 acres)

1947-48 to 1957-58

(Corrected upto 1. 12. 58)

CROPS	1947-48	1948-49	1949-50	1950-51	1951-52	1952-53	1953-54	1954-55	1955-56	1956-57	1957-58
FOOD CROPS											
1. Rice	19006	19424	19528	10007	20301	20778	22010	21336	19486	20055	23235
2. Wheat	85	95	96	24	96	98	98	103	94	133	107
3. Bajra	(b)	1	1	1	1	1	1	1	1	1	1
4. Jowar	3	3	3	1	1	1	1	1	1	1	1
5. Maize	6	7	12	13	10	10	10	9	9	6	7
6. Barley	73	85	87	82	82	86	85	86	88	73	57
7. Gram	208	206	201	200	201	202	203	216	176	165	136
NON FOOD CROPS											
8. Sugar-cane	224	225	227	236	229	246	262	264	259	255	254
9. Rape & Mustard	432	463	477	488	508	507	505	521	543	468	398
10. Cotton	55	55	55	55	57	58	58	58	51	53	51
11. Jute	2059	1877	1561	1711	1779	1907	965	1243	1634	1230	1563
12. Tea	70	73	74	75	82	73	75	74	77	76	76
13. Tobacco	131	126	128	128	130	131	131	135	113	109	107

BOOK REVIEWS

Defense of the Middle East—Problems of American Policy—by John C. Campbell, 392 pp., bibliography, index etc., Published for the Council on Foreign Relations by Harper and Brothers, New York, 1958. Price: $5.00

Encompassing the world's oldest centres of civilization, the Middle East presents to the modern world some of its gravest and most intricate problems. As a meeting place of three continents, as a link in sea and air communications between the East and the West and as a guardian of huge petroleum reserves of the world, the Middle East has long been recognised as a strategically sensitive region. In a world where two power blocs are pitched against each other, the attitudes and outlooks of the region can have a decisive influence on the entire global politics. Since internally this area is torn by national and social conflicts and tensions, and is economically under-developed, it frequently presents situations which, if not handled properly, can spark off a conflict between the major rival world powers, i.e., the Soviet Union and the United States.

John C. Campbell, in his book "Defense of the Middle East" presents the various problems connected with the defence of the area from the American view point and as a part of the global policies and strategy of the United States. In writing this volume, he has benefitted himself from the advice of a study group at the Council on Foreign Relations where he is a Director of Political Studies. His first-hand observations in the Middle East have also been valuable to him in this context.

The book is divided into two sections: the first (128 pp.) presents a brief account of the development of the United States policy in the Middle East as it is centred on the defence of that region against Soviet encroachment. The author maintains that three factors have largely determined the changing character of the so-called Eastern Question: (i) the effort of the Britain to preserve a world empire; (ii) the southward pressure of the great land mass of Russia and; (iii) the forces at work among the people of the Middle East.

He traces the gradual retreat of British power from the area and its replacement after the World War II by an increased American interest in the Middle East. "There is no doubt", he says, "about our concern for peace, for stability, for human welfare, as also for bases, for oil interest, and for resistence to Communism." The events which have had a bearing on the development of United States policy in the area—creation of Israel, postwar Russian demands for bases on the Turkish Straits (1945), and the Suez crisis (1956) have been discussed at length along with the measures adopted in the form of the Eisenhower Doctrine and the Baghdad Pact to safeguard Western interests in the area.

The second part of the book attempts at defining and analysing the political, economic and military problems that confront the United States in the Middle East at present. The first four chapters in this section, viz., "The Meaning of Defense", "The Military Problem: Strategy", "The Military Problem: Bases, Forces and Military Aid", and "Cold War and Diplomacy" contain a bold and clear analysis of the defence problems presented by the area in the event of an all-out nuclear war or a limited war. He stretches his analysis further to cover the implications arising out of the impact of cold war. It is on these considerations that the author bases his conclusions and guides lines for the future policy of the United States in the Middle East.

Of no less interest is a chapter on "Economics and Policy" which discusses the economic aid programmes and their value to the region, particularly in view of the rival economic aid programmes in many countries that have assumed the shape of "an economic warfare, in which the economic cost is accepted because of the political gains".

Although the author's views on the partition of Palestine and Israel's attack on Egypt in 1956 are open to question, one cannot but appreciate his firm grasp of the intricate problems facing the Middle East to-day. His recommendations on the future U.S. policies in the Middle East show his sensitive awareness of the reactions of the Middle East peoples. Notwithstanding the American orientation that characterises the book, a reading of it will be of considerable value to the political geographer as well as to the student of international politics. In it is an ultimate presentation and in its final conclusions the book stands as the embodiment of a particular point of view; but it has to be appreciated that in a world of conflicting ideologies it is the only way out of the convergence of opposing motivations that a higher unity can eventually be attained.

Dr. (Miss) SAIDA K. KARAMAT

2. **An Economic Geography of the Scandinavian States and Finland**—by W. R. Mead, 298 pages, 24 plates and 98 maps and diagrams. University of London Press, Warwick Square, London, 1958.

Geographers have differed in defining the term economic geography. The preposition becomes still more controversial when a regional economic geography is to be written. Such a study tends to become a systematic regional study. Dr. Mead's own point of view is that a study in economic geography may adopt one of two primary approaches, the Systematic or the Unitary. The Systematic approach considers the great economic activities generically: it deals with their description and classification. Such an approach, however, treats them in isolation and many a time the picture of prevailing conditions becomes misleading. The Unitary approach looks at the economy in the aggregate and in process of evolution. Such a study tends to trespass into other fields of knowledge. The writer, however, has selected the unitary approach and has done justice to the subject being fairly within the discipline of geography. In arranging the material, giving headlines to each chapter and in description, the writer has consciously kept his approach in view. Consequently the style of the book is different from many economic geographies written earlier.

The most conspicuous feature of the book is that every geographical aspect has been discussed as a resource and has been evaluated in relation to human development through time. It thus indicates that geography is not a static subject as usually understood.

The plan of the book is well balanced. First five pages explain the writer's view point. Following 67 pages describe the physical resources with long term variations and short term variations. The writer has very rightly emphasized long winters. Man himself has been treated as a resource. Three chapters spread over 76 pages give a detailed study of population and revaluation of resources with the changing human potential. The writer has duly emphasized the human potential in the conquest of physical impediments, e.g. the development of Elecktroteknisk in Norway and Sweden is due to their mountain torrents and human capacity to overcome long frozen winters. Man's role in changing the face of the earth and the role of physical environments in developing the human complex are the two components of geography. A study of the human component in the field of technological advancement has provided a historical geography of the region as well.

A few words about the techniques used will be of great interest. Generally speaking the book is very well illustrated, but at places one wonders about the method used. For example on page 94 the drawing of the parts of the coast-line affected by ice accumulation does not give a satisfactory picture. Even heavy and light lines do not seem to convey the idea. Similarly on page 109 percentage map seems to be l cking in boundaries of areas in which investigations were carried on. Some of the diagrams are very good. On page 115 the evolution of industry in Anderstorp is very expressive of the progress. On the whole the book provides a good study for the techniques of geography.

Dr. (Miss) K. F. Yusuf.

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