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CONTENTS

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(*See inside of the back cover*)

PAKISTAN
GEOGRAPHICAL
REVIEW



Vol. 15 JANUARY, 1960

# RECENT PLUVIOMETRIC CHANGES IN THE ARID AND SEMI-ARID ZONES OF WEST PAKISTAN

By

**MUBASHIR L. KHAN**
*Panjab University, Lahore.*

**Introduction**

It is generally held that the earth is passing through an arid phase of climate and the deserts are rapidly expanding everywhere on the earth. It has been shown by Rodewald (1), Ozava (2), Kincer(3) Angstrom (4) and many others that the general retrogression of climate during the past half century has been due to world-wide rising trend of temperature associated with increased solar radiation. There are others like Rubinstein (5), Brooks (6), Llysgaard (7) Deacon (8), Clayton (9), and Scherhag (10) who have shown that whereas high middle latitudes have witnessed rising temperature trend and increased stormy conditions, in other parts of the world, a steady deterioration of rainfall has been at work and it is in this way that the world climatic pattern is balanced. Abundant climatic data have been collected and analysed to show that whereas the northern and western hemispheres have undergone a progressive climatic recovery, the southern and eastern hemispheres have recorded a slow but continuous decrease of temperature and precipitation, indicating a possibility of the four hemispheres being mutually out of phase. It has been further argued by Ahlmann (11), Brooks (12), Thorarinsson (13), and many others that as a consequence of this arid phase, the great snowfields of the polar basins and Greenland have retreated appreciably during the past half century. Similar conclusions have been advanced by Field (14), Spink (15), Dyson (16), Pillewizer (17) and Mubashir (18) about the mountain glaciers in different parts of the earth.

It has been further argued that the recent retreat of glaciers is not due so much to temperature amelioration as to the decrease in precipitation. The studies of Clayton (op. cit), Butzer (19), Hoovermann (20), Werdecker (21), Looper (22), Codd (23), Forbes (24), Schwarz (25), Monod (26), Mackenzie (27) Hubert (28), Murray (29), Thesiger (30), Stebbing (31), Glover (32), Sabnis (33), Gorrie (34), Ball, (35), Hellstrom (36), Beadnell (37), Sandford (38), etc. have revealed that in the various arid and semi-arid zones of the world a steady pluviometric deterioration has been witnessed which has resulted in the destruction of vegetal cover, lowering of the water-table, and decrease in the volume of rivers. It is the object of the present paper to assess the recent changes of rainfall in the arid and semi arid zones of West Pakistan by examining the secular and periodic variations. In all, the rainfall serie of eight stations have been studied i.e. Karachi, Quetta, Multan, Montgomery, Lahore, Sialkot, Rawalpindi and Peshawar. All these stations except Rawalpindi are situated in the arid and semi-arid zones of West Pakistan. Rawalpindi is located in the dry sub-humid zone.

**Statistical Constants and Randomness of the Series:—**

The length of the series, their arithmatic mean, ($\bar{a}$) the standard deviation ($\sigma$), the average variability (AV) and coefficient of variability (CV) for each station are entered in Table 1. It may be easily gauged from the table that the variability is high everywhere in the region under study, an important characteristic of precipitation common to all deserts of the world. The coefficients of variation range between 77.76% at Karachi and 25.63% at Rawalpindi.

The randomness of the series has been studied by the tests developed by Wallis and Moore (39). The test is based on the distribution of phase-lengths. Since the probability of a phase of length d in a series of d+1 terms is $\frac{2}{(d+1)!}$ for only two of the possible permutations are favourable. In a series of length $N$ there are $N$-d-2 possible phases of length $N$ for d+3 points are required to determine the phase. The probability of a phase d in d+3 terms is

$$= \left\{\frac{1}{(d+1)!} - \frac{1}{(d+2)!}\right\} - \left\{\frac{1}{(d+2)!} - \frac{1}{(d+3)!}\right\} = \frac{d^2+3d+1}{(d+3)!} \qquad \text{1.)}$$

and hence the number of phases of length d is

$$N! \; \frac{2(N-d-2)\,(d^2+3d+1)}{(d+3)\,!} \qquad 1.2$$

*Table 1 showing the Statistical Constants for the annual rainfall at each station*

| Station | Data for the period (years) | $\bar{a}$ (inches) | $\sigma$ (inches) | Va (inches) | AV (inches) | CV % |
|---|---|---|---|---|---|---|
| Karachi | 1871-1955 (85) | 7.60 | 5.91 | 35.02 | 4.66 | 77.76 |
| Quetta | 1881-1955 (75) | 9.04 | 3.31 | 10.99 | 2.43 | 36.60 |
| Multan | 1871-1955 (85) | 6.76 | 3.83 | 14.66 | 3.00 | 56.67 |
| Montgomery | 1871-1955 (85) | 9.99 | 4.77 | 22.74 | 3.59 | 47.74 |
| Lahore | 1871-1955 (85) | 19.40 | 6.45 | 41.66 | 5.26 | 33.45 |
| Sialkot | 1871-1955 (85) | 32.10 | 3.97 | 80.57 | 7.28 | 27.95 |
| Rawalpindi | 1871-1955 (85) | 36.06 | 9.24 | 85.36 | 7.42 | 25.63 |
| Peshawar | 1871-1955 (85) | 13.22 | 4.83 | 23.35 | 3.78 | 36.53 |

$\bar{a}$ Arithmetic Mean — AV: Average Variability

$\sigma$ Standard Deviation — CV: Coefficient of Variability

Va: Variance

Table 2 showing the number of various phase-lengths & the values of chi square for random hypothesis.

| Station | d = 1 | | | d = 2 | | | d ≦ 3 | | | $\frac{6}{7}$ chi square | P |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | obs. | calc. | obs.-calc. | obs. | calc. | obs.-calc. | obs. | calc. | obs. calc. | | |
| Karachi | 30 | 34.1 | —4.1 | 10 | 14.8 | +3.2 | 6 | 4.3 | +1.7 | 2.32 | 0.32 |
| Quetta | 32 | 30.0 | —2.0 | 16 | 13.0 | +3.0 | 3 | 3.8 | —0.8 | 0.84 | 0.67 |
| Multan | 28 | 34.1 | —6.1 | 15 | 14.8 | +0.2 | 8 | 4.3 | +3.7 | 3.66 | 0.17 |
| Montgomery | 33 | 34.1 | —1.1 | 11 | 14.8 | —3.8 | 7 | 4.3 | +2.7 | 2.39 | 0.30 |
| Lahore | 33 | 34.1 | —1.1 | 15 | 14.8 | —0.2 | 5 | 4.3 | +0.7 | 0.12 | 0.94 |
| Sialkot | 44 | 34.1 | —9.9 | 12 | 14.8 | —2.8 | 5 | 4.3 | +0.7 | 3.09 | 0.21 |
| Rawalpindi | 34 | 34.1 | —0.1 | 13 | 14.8 | —1.8 | 5 | 4.3 | +0.7 | 0.27 | 0.87 |
| Peshawar | 26 | 34.1 | —8.1 | 18 | 14.8 | +3.2 | 7 | 4.3 | +2.7 | 2.83 | 0.25 |

Table 3 showing the weighted means of the Annual Precipitation series for the period 1871—1955

| Station | a | b | c |
|---|---|---|---|
| Karachi | 7.6235 | 7.4235 | 7.2843 |
| Quetta | 9.2000 | 9.5192 | 9.8408 |
| Multan | 6.8000 | 7.1209 | 7.2418 |
| Montgomery | 9.9529 | 9.9699 | 9.9462 |
| Lahore | 19.2350 | 19.6621 | 20.0469 |
| Sialkot | 32.1411 | 32.3034 | 33.5627 |
| Rawalpindi | 36.0705 | 35.3212 | 34.8033 |
| Peshawar | 13.2117 | 13.7731 | 13.9296 |

*for Quetta the above period is 1881—1955

Table 4 showing the regression coefficients of the Annual Precipitation for the period 1871-1955.

| Station | a′ | b′ | c′ |
|---|---|---|---|
| Karachi | 7.6235 | +0.2000 | —0.0781 |
| Quetta | 9.2000 | —0.3192 | +0.3240 |
| Multan | 6.8000 | —0.3209 | —0.0791 |
| Montgomery | 9.9529 | —0.0170 | —0.0640 |
| Lahore | 19.2350 | —0.4271 | +0.3423 |
| Sialkot | 32.1411 | —0.1623 | +0.3563 |
| Rawalpindi | 36.0705 | +0.7494 | —0.2865 |
| Peshawar | 13.2117 | —0.5614 | —0.2484 |

The number of possible phases is :—

$$N!\left\{\frac{2N-7}{3}+\frac{2}{N!}\right\} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \qquad 1.3$$

Dividing 1.2 by 1.3 we get

$$\frac{6(d^2+3d+1)(N-d-2)}{(d+3)!\ (2N-7)}$$

From the above mentioned expression which is after Kendall (40) Wallis and Moore have derived a test of significance by grouping the phase lengths into 3 categories; $d=1$, $d=2$ and $d \geqq 3$.

Hoel (41) has confirmed that the results obtained by this test are similar to chi square. Table 2 shows the number of observed and expected phase-lengths. The results show that the data are purely random. A test is hardly necessary but the values of chi square and the probability of finding a larger value are also given.

**Secular Variations**

The secular changes have been analyzed by fitting linear and parabolic curves by the method of orthogonal polynomials as developed by Fisher (42) Beside the long-term trends fitted to the whole interval, 1871-1955, short term trends have also been computed by dividing the above period into two halves.

For the purpose of constructing factorial sums, the series have been split up into two portions and their sums combined to yield progressive sums for the whole series. The method of combination is due to Satakopan (43).

$$S_1=s_1+'s_1$$
$$S_2=n(s\ )+s_2+'s_2$$
$$S_3=\frac{n(n+1)}{2}s_1+n(s_2)+s_3+'s_3$$

in which $s_1$, $s_2$, $s_3$, and $'s_1$, $'s_2$, $'s_3$ are the factorial sums of the first and second portion respectively.

The series $S_1$, $S_2$ and $S_3$ have been divided by suitable divisors to yield numbers of similar magnitude according to the following equations. Using Fisher's expression:—

$$a=\frac{1}{n'}S_1$$
$$b=\frac{1.2}{n'(n'+1)}S_2$$
$$c=\frac{1.2.3}{n'(n'+1)(n'+2)}S_3$$

The values of a, b, c, thus obtained are the weighted means of the series, $S_1$, $S_2$ and $S_3$ and are given in Table 3 for each station. These values have been made independent of n′, the total length of the series by the following equations and a new series a′, b′ & c′ has been constructed

$$a'=a$$
$$b'=a-b$$
$$c'=a-3b+2c$$

These quantities have been tabulated in Table 4 and represent the independent variates in terms of which the rainfall is to be expressed in the form of regression equation. In order to get the coefficients of polynomial to be employed in the expansion of regression function, these values have been divided by suitable divisors in the following manner.

$$X_0 = a'$$

$$X_1 = \frac{6}{n'-1} b'$$

$$X_2 = \frac{30}{(n'-1)(n'-2)} c'$$

These coefficients are given in Table 5. The $X_1$ measures linear trend and $X_2$ the parabolic trend. Table 6 shows the square root of the variances contributed by both degrees individually and as a whole. These have been calculated in the following manner.

$$X_1 = \frac{n'(n'^2-1)}{12} X_1^2$$

$$X_2 = \frac{n'(n'^2-1)(n'^2-4)}{180} X_2^2$$

and taking out the square root.

The Table also shows the standard residue. For a value of X to be statistically significant, it should be at least double the standard residue.

Table 5 showing the coefficients of orthogonal polynomials of the Annual Precipitation for the Period 1871—1955

| Station | $X_1$ ($X10^{-2}$) | $X_2$ ($X10^{-4}$) |
|---|---|---|
| Karachi | +1.4286 | — 3.3663 |
| Quetta | —2.5536 | +18.0000 |
| Multan | —2.2921 | — 3.4094 |
| Montgomery | —0.1214 | — 2.7586 |
| Lahore | —3.0507 | +14.7543 |
| Sialkot | —1.1593 | +15.3577 |
| Rawalpindi | +5.3528 | —12.3491 |
| Peshawar | —4.0100 | —10.7068 |

Table 6 showing the square roots of variances contributed by the Linear and Parabolic Terms and the Standard Residue

| Station | $X_1$ | $X_2$ | $\frac{X_1+X_2}{2}$ | Standard Residue |
|---|---|---|---|---|
| Karachi | 3.23 | 1.67 | 2.57 | 6.01 |
| Quetta | 4.78 | 6.53 | 5.72 | 3.24 |
| Multan | 5.18 | 1.68 | 3.09 | 3.87 |
| Montgomery | 0.88 | 1.38 | 1.14 | 4.85 |
| Lahore | 6.90 | 7.32 | 7.12 | 6.47 |
| Sialkot | 2.62 | 7.62 | 5.69 | 9.09 |
| Rawalpindi | 12.06 | 6.121 | 9.59 | 9.28 |
| Peshawar | 9.07 | 5.3 | 7.44 | 4.78 |

From the table it can be easily seen that only the linear trend at Peshawar and the parabolic trend at Quetta are significant.

The values of $X_1$ show that the rainfall at Karachi during the interval 1871—1955 has been increasing at a rate of 0.014 inches per year. Another similar increase can be noticed in case of Rawalpindi at a rate of 0.053 inches per year. The rainfall at Montgomery has been fairly constant. The rainfall at all other stations has been decreasing at an yearly rate of 0.024″ at Quetta, 0.022″ at Multan, 0.030″ at Lahore, 0.011″ at Sialkot and 0.040″ at Peshawar. The coefficients are illustrated on Map 1. From this, it should not be inferred that by extrapolating these coefficients backward or forward we can fix the exact rainfall amounts in the past or future. For instance, taking into account the present trend, the rainfall of Multan 4000 years hence, should be near 90″ annually. Although there are sufficient proofs to show that the rainfall conditions were decidedly better in the Pre-Aryan times than now, we are not at liberty to assume such a colossal difference of precipitation. Similarly any inference from the present trends to the effect that they will also continue in the future is highly misleading because we do not know when the present trends are going to terminate. Although, by definition, the trend is a smooth, broad motion of the system over a long term of years (Kendall, Op. cit.) the term "long" is relative in the sense that what is long for one purpose, may be short for another. For example, in the present study we have a series of 85 years, and a slow rise or fall from the beginning of the period to the end may be regarded as a trend but if we prossessed rainfall records say, for the last 4000 years, the former rise or fall would appear as a part of a cyclic movement.

**Short term Trends :—**

Of recent, there has been much speculation in regard to the extension of the Great Indian Desert. The first warning to this effect was given by Major Westland Wright, the then Surveyor-General of India (44) who argued that the desert conditions were intensifying in the sub-continent and the advancing waves of sand from the Rajputana Desert were encroaching toward Multan, Lahore, and Delhi, at the rate of half a mile a year. The warning created so much panic that soon after the partition, the Government of Bharat appointed a high power Committee to go through the problem

Table 7 showing the weighted means of the annual precipitation series for the period 1871—1913.

| Station | a | b | c |
|---|---|---|---|
| Karachi | 7.3488 | 7.1900 | 6.9717 |
| Quetta* | 9.8947 | 10.2172 | 10.4028 |
| Multan | 7.1162 | 7.2758 | 7.4756 |
| Montgomery | 10.0465 | 9.7695 | 9.7758 |
| Lahore | 19.6511 | 20.3551 | 20.8867 |
| Sialkot | 32.3488 | 32.8498 | 33.1863 |
| Rawalpindi | 34.3953 | 34.3890 | 34.4073 |
| Peshawar | 13.7441 | 13.9577 | 14.1980 |

*For Quetta the above period is 1881-1918

Table 8 showing the regression coefficients for the annual precipitation series for the period 1871—1913

| Station | a′ | b′ | c′ |
|---|---|---|---|
| Karachi | 7.3488 | +0.1588 | —0.2778 |
| Quetta | 9.8947 | —0.3225 | +0.0487 |
| Multan | 7.1162 | —0.1596 | +0.2400 |
| Montgomery | 10.0465 | +0.2770 | +0.2896 |
| Lahore | 19.6511 | —0.7040 | +0.3592 |
| Sialkot | 32.3488 | —0.5010 | +0.1720 |
| Rawalpindi | 34.3953 | +0.0063 | +0.0429 |
| Peshawar | 13.7441 | —0.2136 | +0.2670 |

Table 9 showing the coefficients of polynomial for the annual precipitation series for the period 1871—1913.

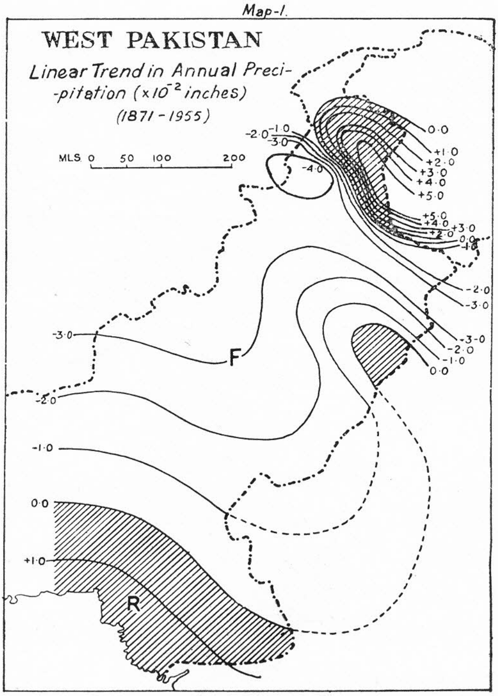
| Station | $X_1$ ($10^{-2}X$) | $X_2$ ($10^{-4}X$) |
|---|---|---|
| Karachi | —2.2685 | —48.3972 |
| Quetta | +5.3750 | +11.5952 |
| Multan | —2.2800 | +41.8118 |
| Montgomery | +3.9571 | +50.4529 |
| Lahore | —10.0571 | +62.5783 |
| Sialkot | —7.1571 | +29.9651 |
| Rawalpindi | +0.9000 | +7.4739 |
| Peshawar | —3.0514 | +46.5156 |

Table 10 showing the weighted means of the annual precipitation series for the period 1914—1955.

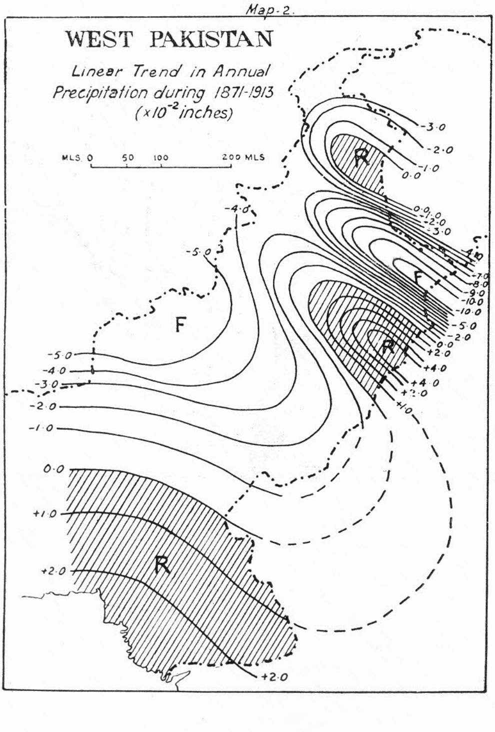
| Station | a | b | c |
|---|---|---|---|
| Karachi | 7.9047 | 7.8172 | 7.7132 |
| Quetta* | 8.4864 | 8.2887 | 7.9352 |
| Multan | 6.4760 | 6.9678 | 7.2571 |
| Montgomery | 9.8571 | 10.0260 | 10.3652 |
| Lahore | 18.8095 | 18.9579 | 19.3820 |
| Sialkot | 31.9280 | 31.6400 | 31.6610 |
| Rawalpindi | 37.7857 | 38.1495 | 38.1440 |
| Peshawar | 12.6666 | 13.6378 | 14.1017 |

*For Quetta the above period is 1919-1955

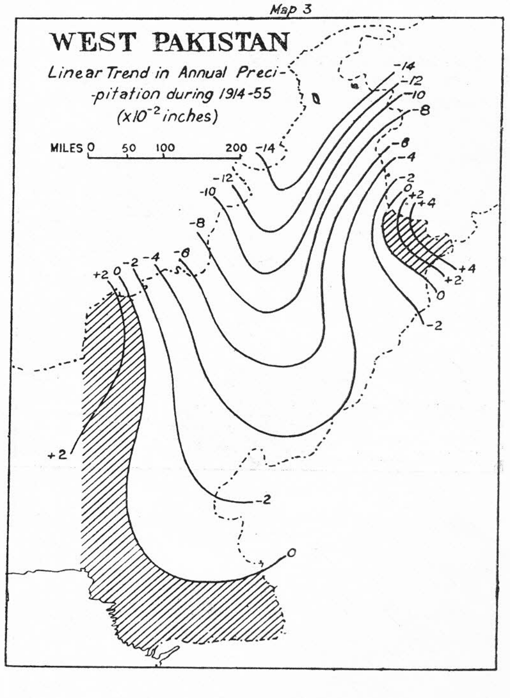
Map-1.

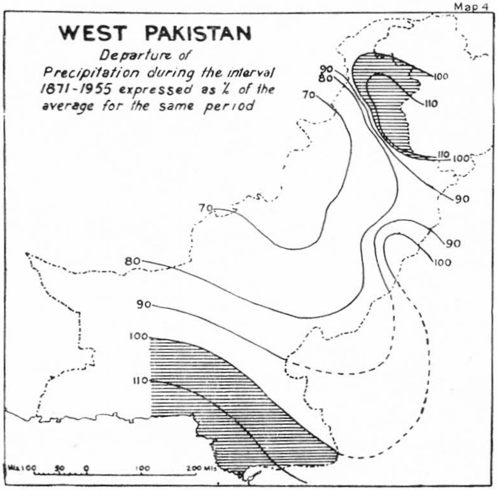


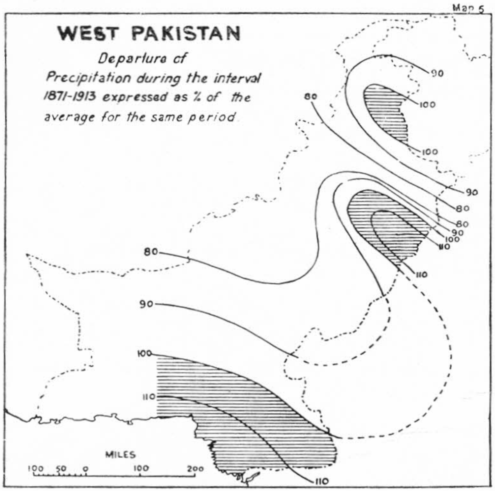

Map-2.




Map 3




Map 4
WEST PAKISTAN
Departure of
Precipitation during the interval
1871-1955 expressed as % of the
average for the same period
70
80
90
100
110
Mls 100 50 0 100 200 Mls


Map 5
WEST PAKISTAN
Departure of
Precipitation during the interval
1871-1913 expressed as % of the
average for the same period
80
90
100
110
MILES
100 50 0 100 200

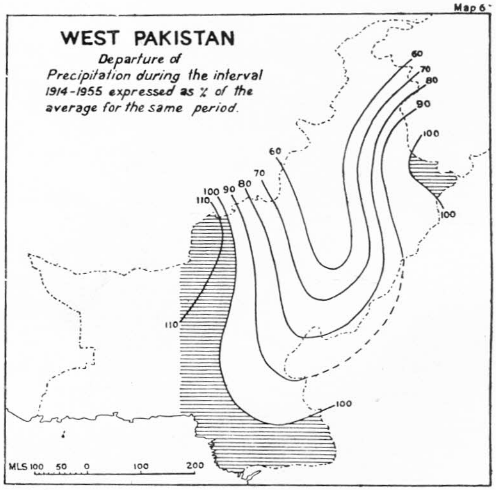

Map 6
WEST PAKISTAN
Departure of
Precipitation during the interval
1914-1955 expressed as % of the
average for the same period.
60
70
80
90
100
110
MLS 100 50 0 100 200

Table 11 showing the regression coefficients for the annual precipitation series for the period 1914—1955.

| Station | a′ | b′ | c′ |
|---|---|---|---|
| Karachi | 7.9047 | +0.0875 | —0.1205 |
| Quetta | 8.4864 | +0.1977 | —0.5093 |
| Multan | 6.4760 | —0.4918 | +0.0868 |
| Montgomery | 9.8571 | —0.1689 | +0.5095 |
| Lahore | 18.8095 | —0.1484 | +0.6998 |
| Sialkot | 31.9280 | —0.2880 | +0.3300 |
| Rawalpindi | 37.7857 | +0.3638 | —0.3748 |
| Peshawar | 12.6666 | —0.9712 | —0.0434 |

Table 12 showing the coefficients of polynomial for the annual precipitation series for the period 1914—1955.

| Station | $X_1$ ($10^{-2}$X) | $X_2$ ($10^{-4}$X) |
|---|---|---|
| Karachi | + 1.2811 | — 22.0413 |
| Quetta | + 3.2094 | —114.7072 |
| Multan | — 7.2005 | + 15.8771 |
| Montgomery | — 2.4729 | + 93.1955 |
| Lahore | — 2.1728 | +128.0043 |
| Sialkot | + 4.2167 | + 60.3621 |
| Rawalpindi | — 5.3265 | — 68.5567 |
| Peshawar | —14.2196 | — 8.0370 |

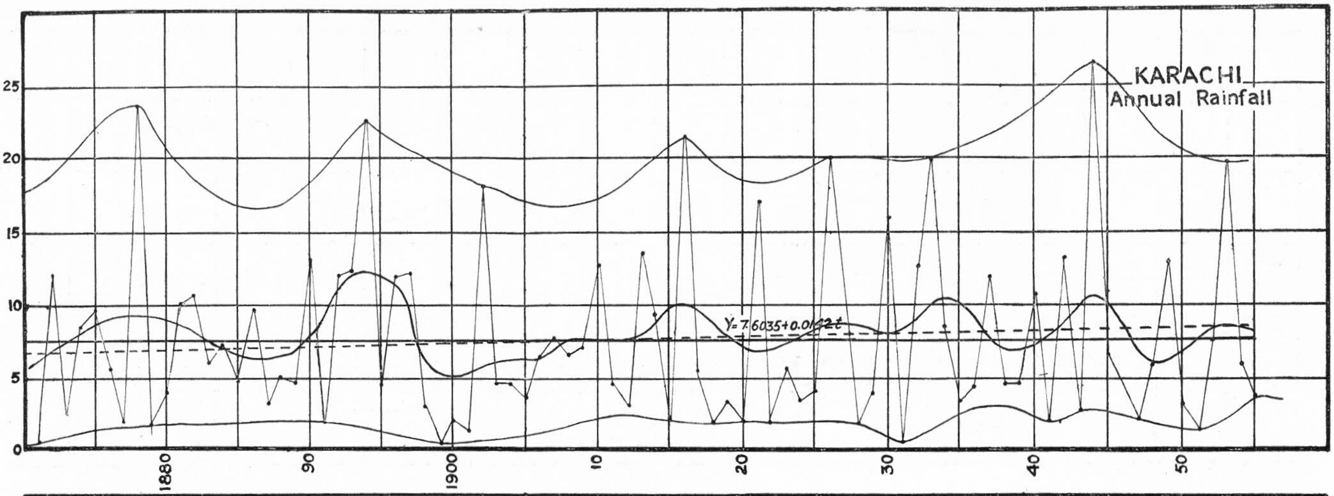
Table 13 showing the square roots of variances contributed by the linear and Parabolic Terms and the Standard Residue

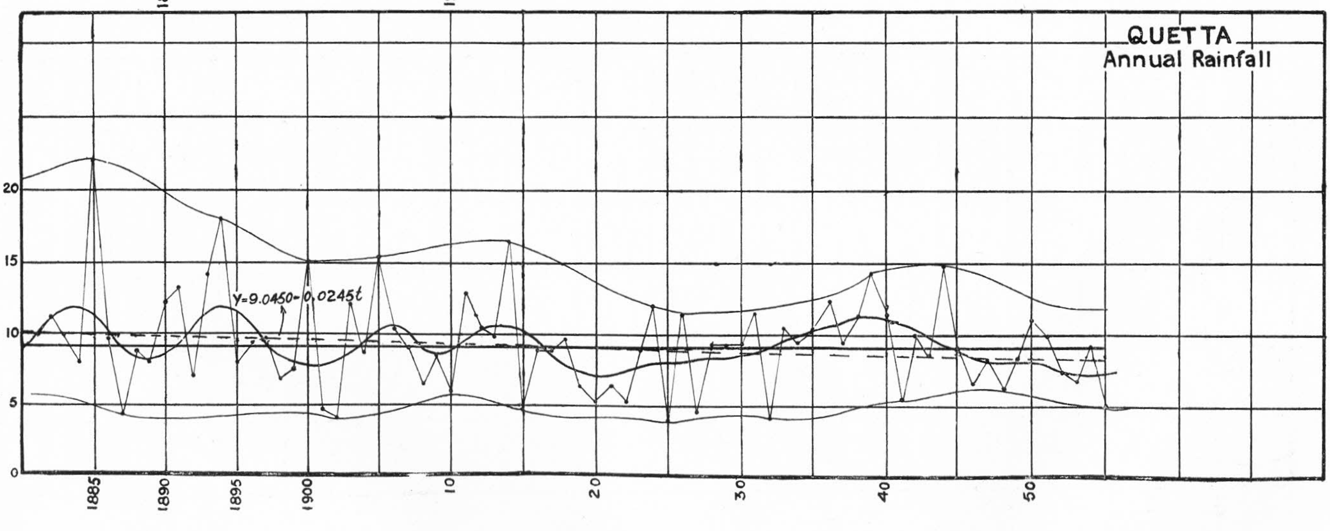
| Station | 1871—1913 | | | | 1914—1955 | | | |
|---|---|---|---|---|---|---|---|---|
| | $X_1$ | $X_2$ | $\frac{X_1+X_2}{2}$ | Standard Residue | $X_1$ | $X_2$ | $\frac{X_1+X_2}{2}$ | Standard Residue |
| Karachi | 1.84 | 4.7 | 3.36 | 5.43 | 1.00 | 1.88 | 1.50 | 6.73 |
| Quetta | 3.63 | 0.76 | 2.53 | 3.86 | 2.08 | 7.10 | 5.23 | 2.53 |
| Multan | 1.85 | 3.77 | 2.97 | 3.70 | 5.65 | 1.35 | 4.11 | 4.20 |
| Montgomery | 3.22 | 4.55 | 3.94 | 4.65 | 1.94 | 7.92 | 5.77 | 4.98 |
| Lahore | 8.18 | 5.64 | 7.03 | 7.19 | 1.70 | 10.87 | 7.78 | 5.69 |
| Sialkot | 5.82 | 2.70 | 4.54 | 9.51 | 3.31 | 5.12 | 4.32 | 8.98 |
| Rawalpindi | 0.73 | 0.67 | 0.70 | 27.69 | 4.18 | 5.83 | 5.07 | 9.65 |
| Peshawar | 2.48 | 4.20 | 3.45 | 5.65 | 11.17 | 0.68 | 7.91 | 3.90 |

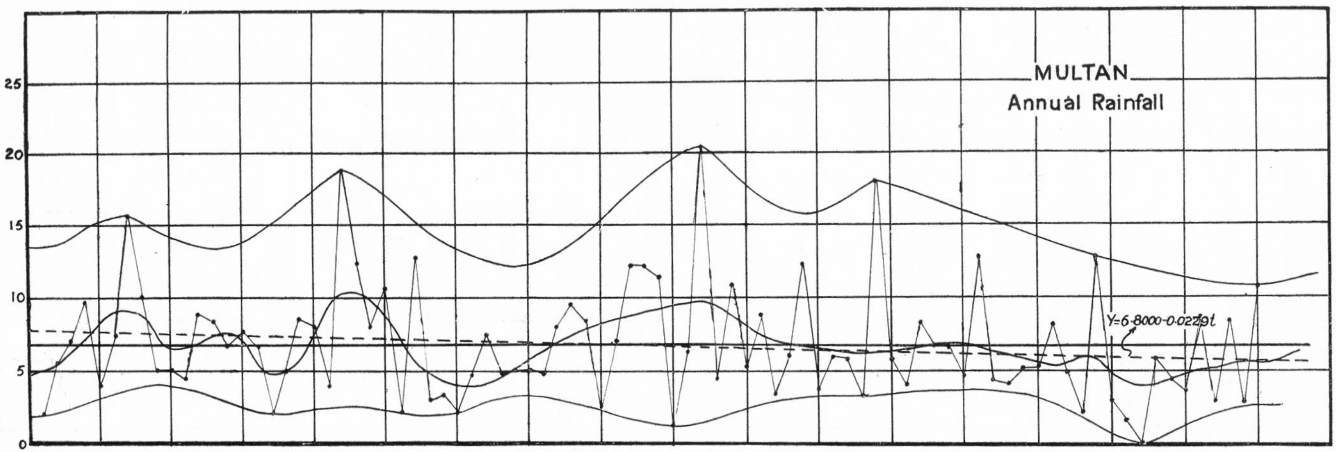
Table 14 showing the Departure (%) of Precipitation based on the linear Trend during the Intervals 1871—1955, 1871—1913 & 1914—1955 expressed as percentage of the averages for the respective periods.

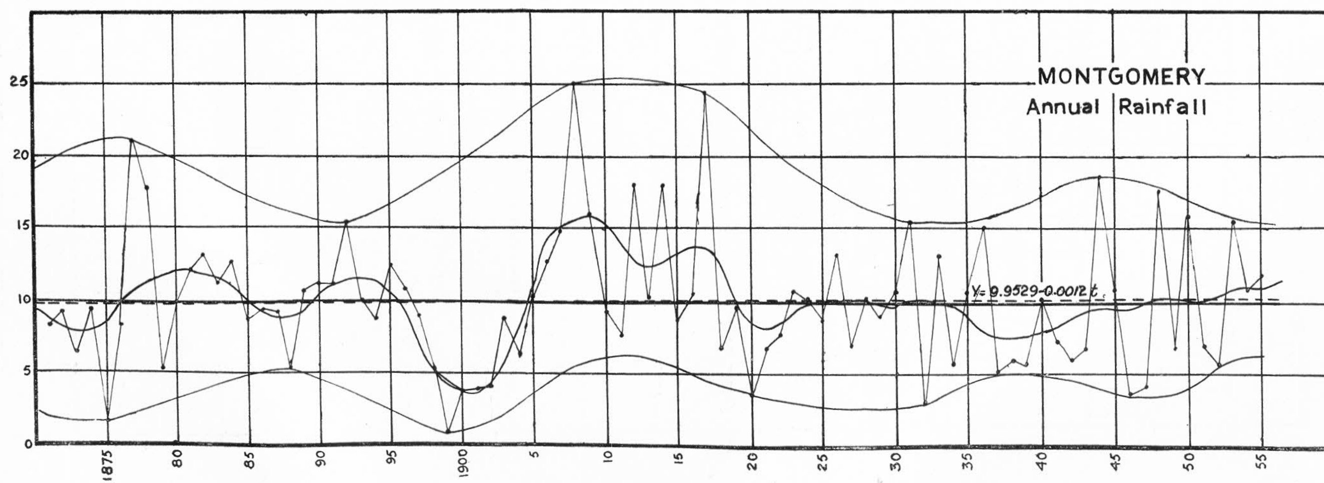
| Station | 1871—1955 | 1871—1913 | 1914—1955 |
|---|---|---|---|
| Karachi | 115.74 | 113.23 | 106.64 |
| Quetta | 77.40 | 76.74 | 113.99 |
| Multan | 71.38 | 86.22 | 54.56 |
| Montgomery | 98.98 | 116.91 | 89.74 |
| Lahore | 86.52 | 75.85 | 95.25 |
| Sialkot | 97.07 | 90.50 | 105.42 |
| Rawalpindi | 112.60 | 101.12 | 94.92 |
| Peshawar | 74.20 | 90.46 | 58.70 |

and make recommendations to prevent the march of the desert. The recent investigations conducted by Pramanik, Hariharan and Ghose ([45]) and Premanik and Jagannathan ([46]) have, on the contrary revealed that there has been no significant


KARACHI
Annual Rainfall
Y=7.6035+0.0142t
0
5
10
15
20
25
1880
90
1900
10
20
30
40
50


QUETTA
Annual Rainfall
Y=9.0450-0.0245t
0
5
10
15
20
1885
1890
1895
1900
10
20
30
40
50


MULTAN
Annual Rainfall
Y=6·8000-0·0229t
25
20
15
10
5
0


MONTGOMERY
Annual Rainfall
Y= 9.9529-0.0012 t
25
20
15
10
5
0
1875
80
85
90
95
1900
5
10
15
20
25
30
35
40
45
50
55

secular variation of rainfall in and around the Rajasthan Desert. The present writer has divided the interval 1871—1955 into two portions and fitted linear and parabolic trends to each part in order to study the short term trends. This analysis is also intended to throw further light on the long-term trends, especially on their termination, if any.

The weighted means, and the coefficients of regression and of polynomials of the precipitation series for the period 1871—1913 are entered in Tables 6 to 8. The coefficients of linear trend are illustrated on Map 2. The weighted means and the coefficients of regression and of polynomials of the precipitation series for the period 1914—1955 are given in Tables 9 to 11. The coefficients of linear trend are illustrated on Map 3. A comparison of the linear trends for the two periods shows that the latter period (1914-1955) has witnessed considerable deterioration of pluviometric conditions. Not only has the rate of increase slowed down in the southern part of Lower Indus Valley, increassing trend has mostly terminated in the sub Himalayan areas of the country. In the arid and semi-arid zones the rainfall has considerably deteriorated. At Sialkot and Quetta however, the negative trend has changed into positive. The total departure of rainfall of the whole interval under study and the two sub-periods is given in Table 14 illustrated on Maps 4 to 6.

**Periodic Variations.—**

These variations have been studied by the method of periodogram analysis which is briefly as follows. Let a Fourier series, be,

$$f(t)=a_0+a_1 \cos\frac{\pi t}{\lambda_1}+a_2 \cos\frac{2\pi t}{\lambda_1}+ \ldots\ldots\ldots\ldots$$

$$+b_0+b_1 \sin\frac{\pi t}{\lambda_1}+b_2 \sin\frac{2\pi t}{\lambda_1}+\ldots\ldots\ldots\ldots$$

In the representation of observed series, since the periods of every term is a multiple of the fundamental period the Fourier series is restricted in scope. A more general scheme is as follows:—

$$f(t)=a_0+a_1 \cos\frac{2\pi t}{\lambda_1}+a_2 \cos\frac{2\pi t}{\lambda_2}+\ldots\ldots\ldots$$

$$b_0+b_1 \sin\frac{2\pi t}{\lambda_1}+b_2 \sin\frac{2\pi t}{\lambda_2}+\ldots\ldots\ldots\ldots\ldots$$

Supposing we want to find whether a series contains a haronomic term with period $\mu$. We construct the quantities

$$A=\frac{2}{n}\sum_{j=1}^{n} n j \cos\frac{2\pi j}{\mu} \qquad B=\frac{2}{n}\sum_{j=1}^{n} nj \sin\frac{2\pi j}{\mu}$$

and write $R^2=A^2+B^2$

Thus R remains small unless the trial period $\mu$ approaches the real period. This forms the basis of periodogram analysis. $R^2$ which is called the intensity of the periodogram is illustrated as a function of $\mu$ and graphed as ordinate against $\mu$ as abscissa. The diagram thus obtained is called a periodogram. Before using $R^2$ for the periodogram it is reduced for the sake of comparability. This is done by multiplying $R^2$ by $\frac{n}{N}$ where n is the number of observations used in the analysis for a particular $\mu$ and N is the total number of observations. If this figure shows peaks at certain points the corresponding periodicities are scrutinized for the sake of significance and waves are drawn for these periods. The amplitude (R) is given by

$$R=\sqrt{A^2+B^2}$$

and the phase angle $\varnothing$ by

$$\tan \varnothing = \frac{A}{B}$$

As mentioned earlier, the quantity $R^2$ depends on the quantities A & B. Supposing that our trial period $\mu$ is aninteger, then we write down the series in rows of $\mu$ as follows:-

| | | | | |
|---|---|---|---|---|
| $\mu_1$ | $\mu_2$ | $\mu_3$ | * | $\mu_\mu$ |
| $\mu_{\mu+1}$ | $\mu_{\mu+2}$ | $\mu_{\mu+3}$ | * | $\mu_{2\mu}$ |
| * | * | * | * | |
| $\mu_{(p-1)\mu+1}$ | $\mu_{(p-1)\mu+2}$ | $\mu_{(p-1)\mu+3}$ | * | $\mu_{p\mu}$ |
| Mean = $m_1$ | $m_2$ | $m_3$ | | $m_\mu$ |

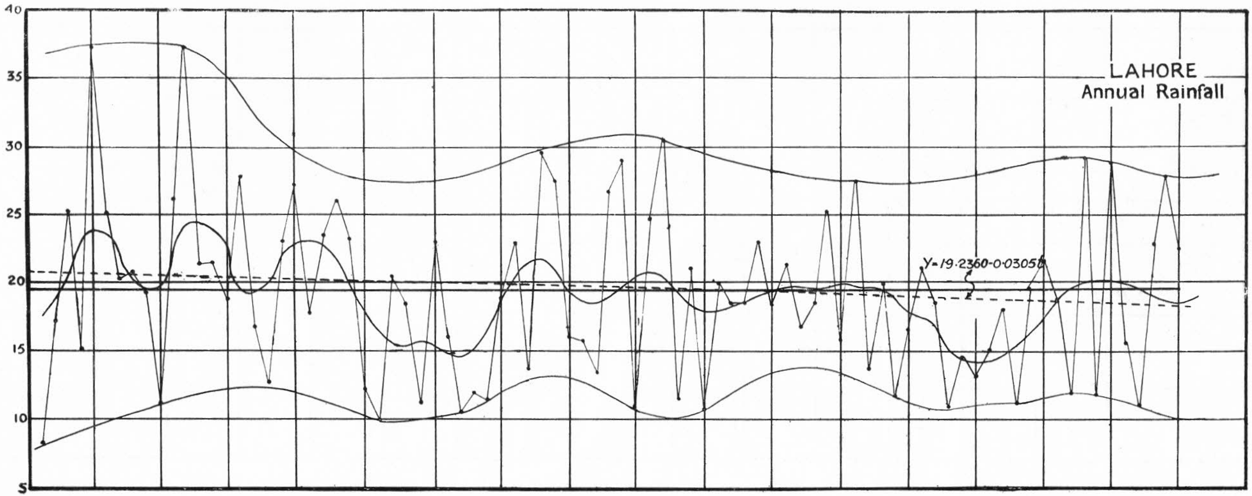
This sort of array is known as Buys-Ballot Schedule. From the means obtained by each column in the average row, we then from the sum

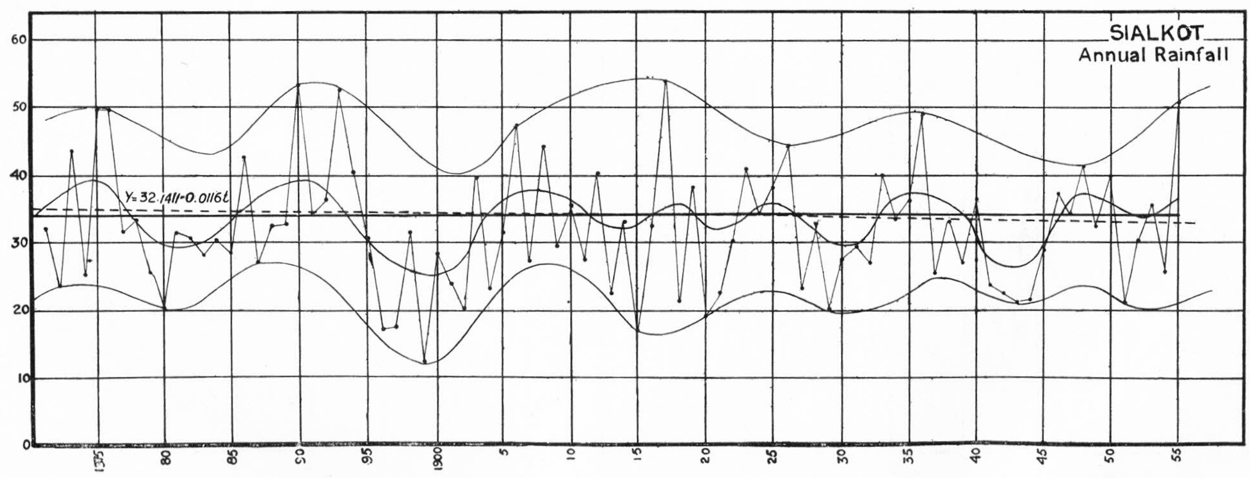
$$A=\frac{2}{p\mu}\sum_{j=1}^{\mu}\left(mj \sin \frac{2\pi j}{\mu}\right)\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$B=\frac{2}{p\mu}\sum_{j=1}^{\mu}\left(mj \cos \frac{2\pi j}{\mu}\right)\ldots\ldots\ldots\ldots\ldots\ldots$$

Tabie 15 showing the Fourier Coefficients and $R^2$ for the period ($\mu$) showing maximum amplitude in each Periodogram.

| Station | $\mu$ | A | B | $R^2$ |
|---|---|---|---|---|
| Karachi | 4 | —2.2500 | —2.1000 | 9.4725 |
| Quetta | 3 | +0.4000 | +1.1547 | 1.4933 |
| Multan | 4 | —1.3500 | +0.8500 | 2.5445 |
| Montgomery | 5 | —0.0552 | +1.3576 | 1.8460 |
| Lahore | 8 | —2.6993 | —1.2873 | 8.9541 |
| Sialkot | 4 | —2.0500 | —3.7500 | 18.2650 |
| Rawalpindi | 4 | +0.5500 | —4.6000 | 21.4625 |
| Peshawar | 3 | +0.1334 | +1.3920 | 1.9553 |


LAHORE
Annual Rainfall
Y=19.2360-0.03050t
40
35
30
25
20
15
10
5


SIALKOT
Annual Rainfall
Y=32.1411-0.0116t
60
50
40
30
20
10
0
1875
80
85
90
95
1900
5
10
15
20
25
30
35
40
45
50
55

This is the practical method of searching for periodicities.

The writer has constructed 296 Buys-Ballot Schedules for trial periods ranging from 3 to 24 years. The periods below three years have not been considered for the simple reason that data for shorter time intervals than the year are required for their study. Another limitation set by the data concerns the largest period that should be investigated and this depends as to how many repetitions of a cycle are considered ample proof of its existence. The largest period of which we can have at least 3 repetitions in 85 observations is 28.3 years. The writer has therefore not considered periods exceeding 24 years in length because for at least one station i.e. Quetta, the series consists of 75 observations.

The periodograms for all stations being studied in this paper will be found elsewhere (47). Here we shall limit our discussion only to such periods as exhibit highest amplitude in each periodogram. These periods ($\mu$), their Fourier coefficients (A & B) and their squared amplitudes ($R^2$) are given in Table 15.

Various tests have been proposed in order to investigate whether a certain period showing maximum amplitude in a periodogram is statistically significant or not. Some of the important tests have been given by Schuster (48), Fisher (49) Turner (50), Walker (51), Brunt (52) and Bartles (53). Here, we propose to utilise only the first two tests.

In his earliest test, Schuster proposed the mean amplitude to be expected with random data as a measure of testing the significance of a period. He applied the term "expectancy" to this mean amplitude ($E_1$) which is given by the formula

$$E_1 = \sigma \sqrt{\frac{\pi}{N}}$$

where all symbols have the usual meaning. To test the significance of a certain period, the corresponding amplitude is dividued by $E_1$ to give $k$ and the probability of getting out of mere chance, as large an amplitude as the one being investigated is calculated

Table 16 showing the Amplitudes of the Periodicities of Table 13 and their significance.

| Station | $\mu$ | R | $E_1$ | $k$ | $P(kE_1)$ | $E_2$ | $k$ | $P(kE_2)$ |
|---|---|---|---|---|---|---|---|---|
| Karachi | 4 | 3.05 | 1.15 | 2.65 | 0.0040 | 1.28 | 2.38 | 0.0037 |
| Quetta | 3 | 1.23 | 0.67 | 1.83 | 0.0742 | 0.75 | 1.64 | 0.0672 |
| Multan | 4 | 1.57 | 0.73 | 2.15 | 0.0273 | 0.83 | 1.89 | 0.0273 |
| Montgomery | 5 | 1.34 | 0.91 | 1.47 | 0.1826 | 1.03 | 1.30 | 0.1826 |
| Lahore | 8 | 2.99 | 1.23 | 2.43 | 0.0100 | 1.39 | 2.15 | 0.0100 |
| Sialkot | 4 | 4.27 | 1.72 | 2.48 | 0.0083 | 1.94 | 2.20 | 0.0082 |
| Rawalpindi | 4 | 4.64 | 1.77 | 2.62 | 0.0045 | 2.00 | 2.32 | 0.0045 |
| Peshawar | 3 | 1.38 | 0.92 | 1.50 | 0.1653 | 1.04 | 1.30 | 0.1826 |

by the formula

$$P\left({}_kE_1\right) = e^{-\frac{\pi}{4}k^2}$$

Similarly, we can calculate the expectancy of the squared amplitudes $\left(E_2^2\right)$ of a Fourier series by the formula

$$E_2^2 = \frac{4\sigma^2}{N}$$

and the probability that any amplitude exceeds ${}_kE_2^2$ by the formula

$$P\left({}_kE_2^2\right) = e^{-k}$$

Similarly the expectancy for the square-root of the average squared amplitude is

$$E_2 = \frac{2\sigma}{\sqrt{N}}$$

and the probability that any amplitude exceeds ${}_kE_2$ is

$$P\left({}_kE_2\right) = e^{-k^2}$$

The amplitudes (R) of periods showing maximum ordinate in each periodogram and the probabilities of getting equivalent amplitudes out of mere chance are given in Table 16. For the sake of illustration we shall deal with two cases. Entering the last but one column of the above-mentioned table we find that the amplitude of the 4-year period in the rainfall of Karachi is 2.38 times the expectancy ($E_2$) for which the value of P ($kE_2$) is 0.0037 which means that the probability that this amplitude is a product of pure chance is 37 in 10,000. We may therefore, feel a real effect. On the contrary, in the case of Montgomery and Peshawar we find that the amplitudes of the corresponding periods are 1.30 times the expectancy ($E_2$) for which the value of P ($kE_2$) is 0.1826 which means that in one case out of about five, chance fluctuations will cause the amplitude to be even greater than this and therefore it is difficult to draw any conclusion as to the reality of the period.

In Fisher's test of significance, let the ratio of the square of the amplitude of a given period to the sum of the squares of the amplitudes for the complete Fourier sequence be

$$g = \frac{R^2}{\sum_{j=1}^{n} R_i^2}$$

Then we may represent the probability integral as follows

$$P_g = n\left(1-g\right)^{n-1} - \frac{n(n-1)}{2}\left(1-2g\right)^{n-1} + \ldots\ldots\ldots\ldots + (-)^{k-1}\frac{n!}{k!\,(n-k)!}\left(1-kg\right)^{-1},$$

where $k$ is the largest integer less than $\frac{1}{g}$. Finally, the probability that the largest of n terms should exceed a given g is n times the value given by

$$P_g = \left(1-g\right)^{n-1}$$

and has been shown to be exactly

$$P_{g} = n\left(1-g\right)^{n-1} - \ldots\ldots\ldots\ldots + \left(-\right)^{n-1}\frac{n!}{k!(n-k)!}\left(1-kg\right)^{n-1},$$

where k is the largest integer less then $\frac{1}{g}$ or

$$P_g = n\left(1-g\right)^{n-1}$$

where n =(N−1)/2 for add values of N &

n =(N−2)/2 for even values of N.

For all stations except Quetta, n=42, so that for 5% level

$$P_g = 42(1-g)^{41} = 0{\cdot}05$$

Solving the equation we get the value of g=0.1508

For Quetta $n$=37, so that for 5% level

$$P_g = 37\,(1-g)^{36} = 0{\cdot}05$$

Solving the above equation, we get

g=0.1676

From Fisher's requirement that

$$P_g = n\left(1-g\right)^{n-1}$$

should not exceed 0.05, it follows that for all stations except Quetta

$$g = \frac{R^2}{\sum\limits_{i=1}^{n} R^2_i} = 0{\cdot}1508$$

For Quetta

$$g = \frac{\frac{R^2}{n}}{\sum_{i=1}^{n} R^2_i} = 0{\cdot}1676$$

Substituting

$$\sum_{i=1}^{n} R^2_i = 2v$$

where $v$ is the estimate, we derive the values of $R^2$ which give for a period of that sequence the minimum that will satisfy Fisher's test. These values are given for each station in the second column of Table 17. It will be seen that the 4-year period at Karachi nearly approaches the significance limit. All other periods fall short of Fisher's expectancy. This should not mean that these periods are spurious. Although statistically insignificant, these may, nevertheless be having some effect. Possibly, it is mainly due to the shortness of the observational interval that it is difficult to prove their reality (54)

Here, we may also utilize Davis's concept of energy spectrum (55) which is based on the well known theorems of Bessel and Parseval. The first theorem proves that the variance of the function f (t) can be expressed in terms of the Fourier coefficients in the following form :—

Table 17 showing the minimum values of $R^2$ that will satisfy Fisher's test of significance (5% level)

| Station | R2 | R | R as% of the mean rainfall |
|---|---|---|---|
| Karachi | 10.5620 | 3.25 | 42.76 |
| Quetta | 3.6838 | 1.92 | 21.23 |
| Multan | 4.4214 | 2.13 | 31.50 |
| Montgomery | 6.8583 | 2.61 | 26.12 |
| Lahore | 12.5646 | 3.54 | 18.24 |
| Sialkot | 24.2999 | 4.93 | 15.35 |
| Rawalpindi | 25.7445 | 5.08 | 14.08 |
| Peshawar | 7.0423 | 2.65 | 20.04 |

$$\sigma^2=\tfrac{1}{2}\sum_{n=1}^{\infty}\left(A_n^2+B_n^2\right)=\tfrac{1}{2}\sum_{n-1}^{\infty}R^2_n$$

This is proved by noting that the arithmetic average of f (t) is equal to $\frac{1}{2}$ $A_0$. So that we have

$$\sigma^2=\frac{1}{2a}\int_{-a}^{a}\left[f^2(t)-(\tfrac{1}{2}A_0^2)\right]dt=$$

$$\tfrac{1}{2}\sum_{n=1}^{\infty}(A_n^2+B^2_n)\quad\tfrac{1}{2}\sum_{n=1}^{\infty}R^2_n$$

The theorem of Parseval states that if two functions f(t) and g(t) belong to the Fourier sequence and their coefficients are respectively

$f(t)=\frac{1}{2}A_0, A_1, A_2 \ldots\ldots\ldots\ldots; B_1, B_2, B_3 \ldots\ldots\ldots\ldots;$
$g(t)=\frac{1}{2}a_0, a_1, a_2 \ldots\ldots\ldots\ldots; b_1, b_2, b_3 \ldots\ldots\ldots\ldots;$

then

$$\frac{1}{a}\int_{-a}^{a}f(t)\,g(t)\,dt=\tfrac{1}{2}A_0\,a_0+\sum_{n=1}^{\infty}A_n\,a_n+\sum_{n=1}^{\infty}B_n\,b_n$$

From the first theorem, Davis derives the energy associated with a single period $\mu$ as

$$E(\mu)=\frac{R^2(\mu)}{2\sigma^2}$$

and for a set of $n$ harmonic terms

$$\sum E_n=\frac{\Sigma R^2(\mu s)}{2\sigma}$$

and after $n$ terms have been removed, the variance $\sigma_p^2$ of the series is given by the formula

$$\sigma_p^2=\left(1-\sum E_n\right)^{\sigma^2}$$

From the second theorem, Davis derives the mutual energy of two series, f(t) and g (t) namely $E_{fg}$ by the formula

$$E_{fg}=\frac{\Sigma(A_n\,a_n+B_n\,b_n)}{2\sigma f\ \sigma g}$$

Table 18 showing the energy contribution (E) of the periods being tested to the total energy of the series.

| Station | $\mu$ | $R^2$ (inches) | E (%) |
|---|---|---|---|
| Karachi | 4 | 9.47 | 13.52 |
| Quetta | 3 | 1.49 | 6.77 |
| Multan | 4 | 2.54 | 8.66 |
| Montgomery | 5 | 1.84 | 4.04 |
| Lahore | 8 | 8.95 | 10.74 |
| Sialkot | 4 | 18.26 | 11.33 |
| Rawalpindi | 4 | 21.46 | 12.57 |
| Peshawar | 3 | 1.95 | 4.17 |

Table 19 showing the reduction of variance effected by the periods under consideration

| Station | $\sigma^2$ | $\sigma_p^2$ | $\sigma^2 - \sigma_p^2$ |
|---|---|---|---|
| Karachi | 35.02 | 4.37 | 30.65 |
| Quetta | 10.99 | 0.74 | 10.25 |
| Multan | 14.66 | 1.27 | 13.39 |
| Montgomery | 22.74 | 0.92 | 21.82 |
| Lahore | 41.66 | 4.47 | 37.19 |
| Sialkot | 80.57 | 9.13 | 71.44 |
| Rawalpindi | 85.36 | 10.73 | 74.63 |
| Peshawar | 23.35 | 0.97 | 22.38 |

Table 18 gives the values of $R^2$ for the periods being tested for significance and their energy (E) expressed in percentage of the total. The meaning of the latter values is clear. If the total movement of the series be denoted by 100, then in the first case, for instance, the energy contributed by the 4-year period is 13.52 of the total and so on.

Table 19 shows the reduction of variance effected by the period under consideration at each station.

**Moving Averages:—**

It has often been demonstrated that the use of Fourier analysis in the meteorological series does not yield satisfactory results. It is mostly because of the fact that interfering processes are occurring almost always in the atmosphere and there develops only a tendency for periodicities with preference of certain rhythms but no persistent periods. Under these conditions, non-recurrent curves appear to be suitable and of these the logistic most useful. But even these curves involve considerable amount of time and labour and the writer has preferred the use of integrated averages which accomplishes much the same result with relative ease and comfort. The data have been subjected to a five-year graduation and then a further 3-year graduation

$$v_1 = (\mu_1 + \mu_2 \ldots\ldots\ldots\ldots \mu_5)$$
$$v_2 = (\mu_2 + \mu_3 \ldots\ldots\ldots\ldots \mu_6)$$
$$v_3 = (\mu_3 + \mu_4 \ldots\ldots\ldots\ldots \mu_7) \text{ etc.}$$

and the of the second graduation is to give

$$w_1 = (v_1 + v_2 + v_3)$$
$$w_2 = (v_2 + v_3 + v_4)$$
$$w_3 = (v_3 + v_4 + v_5)$$

The final values for all stations are shown on the graphs of actual annual rainfall along with the upper and lower envelopes. The curves of moving averages charted on the rainfall graphs show several peaks and troughs and these should not be taken as definitely of periodic nature. It can be easily gauged from the choppy appearance and the frequent -zig-zags of the curves that crests and troughs do not recur at equal intervals and that there is no uniformity in the amplitude of oscillation. Slutzky and Yule ([54]) have shown that these oscillations are not real and are produced by our own arithmetical processes. Nevertheless the method of moving averages serves useful purpose in that it gives smoothest possible locus of points toward which the original series can be reduced. Various methods have been suggested by several authorities for assigning length to cycles created by moving averages. Of these methods, Dodd's objective counting ([56]) and Frisch's super-spectrum are worth mentioning.

The curves of running averages, at all stations except at Quetta, show a well marked deficit of rainfall during the interval 1895—1905. This dry phase was immediately followed by a wet one especially at Multan, Montgomery and Peshawar and lasted up till about 1920. For the rest of distribution and minor details, the reader should consult the curves individually.

**Pentad Averages :**

Table 20 contains the pentad averages of annual rainfall. The overlapping pentad means are given in Table 21. The integration has been performed by the simple formula $(M_{0-1} + M_0 + M_{0+1})/3$ where M is the pentad mean.

**Decennial Means:**

Table 22 contains the decennial means of rainfall. The integrated averages are presented in Table 29, the integration having been performed in the similar manner as in the case of pentad means (the M of that formula being the decennial average in this case.

Table 20. Pentad averages of Annual Precipitation

| Station | 1876/80 | 1881/85 | 1886/90 | 1891/95 | 1899/900 | 1901/05 | 1906/10 | 1910/15 | 1916/20 | 1921/25 | 1925/30 | 1931/35 | 1946/40 | 1941/45 | 1946/50 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Karachi | 5.66 | 7.46 | 7.75 | 7.13 | 10.83 | 5·96 | 6.48 | 8.08 | 6.61 | 6.98 | 6.50 | 10.16 | 9.12 | 7.20 | 10.22 | 5·59 | 7.81 |
| Quetta | — | — | 11.94 | 8.45 | 12.09 | 9.55 | 8.97 | 7.85 | 10.59 | 7.62 | 7.09 | 8.45 | 7.08 | 11.39 | 9.44 | 7.88 | 7.56 |
| Multan | 5.65 | 8.54 | 7.17 | 5·94 | 10.62 | 4.98 | 4.84 | 6.60 | 8.72 | 9.42 | 6.74 | 7.16 | 5.26 | 6.35 | 6.19 | 3.13 | 6·79 |
| Montgomery | 7.10 | 12.42 | 11.44 | 9.14 | 11.52 | 5.91 | 6.65 | 15.37 | 12.45 | 10.99 | 8.93 | 10.01 | 9.35 | 8.48 | 9.98 | 9.96 | 10.25 |
| Lahore | 20.82 | 19.31 | 25.06 | 21.50 | 20.52 | 15.38 | 12.44 | 21.19 | 13.95 | 19.19 | 19.11 | 19.67 | 17·92 | 15.57 | 16.13 | 19.54 | 19.07 |
| Sialkot | 34.66 | 32.07 | 29.90 | 37.72 | 38.93 | 21.67 | 27.87 | 37.02 | 28.32 | 33.40 | 33.42 | 29.59 | 33.35 | 34.52 | 23.55 | 37.28 | 32.77 |
| Rawalpindi | 34.92 | 34.03 | 33.90 | 37.14 | 37.31 | 29.25 | 26.98 | 43.25 | 32.79 | 40.12 | 36.47 | 39.57 | 35.54 | 39.74 | 38.99 | 39.77 | 33.02 |
| Peshawar | 14.28 | 26.58 | 14.20 | 10.91 | 15.73 | 11.81 | 12.21 | 16·13 | 14.01 | 14.29 | 13.42 | 13.74 | 14.09 | 12.52 | 11.13 | 10.41 | 9.74 |

Table 21 Integrated Pentad Means of Annual Precipitation

| Station | 1876/80 | 1881/85 | 1886/90 | 1891/95 | 1899/900 | 1901/05 | 1906/10 | 1910/15 | 1916/20 | 1921/25 | 1925/30 | 1931/35 | 1946/40 | 1941/45 | 1946/50 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Karachi | 6.96 | 7.45 | 8.57 | 7.97 | 7.75 | 6.84 | 7.06 | 7.22 | 6.69 | 7·88 | 8.59 | 8·83 | 8.85 | 7.67 | 7.87 |
| Quetta | — | — | 10.83 | 10.03 | 10.14 | 8.73 | 9.08 | 8.69 | 8.43 | 7.72 | 7.54 | 8.97 | 9.30 | 9.57 | 8.29 |
| Multan | 7.12 | 7.22 | 7.91 | 7.18 | 6.81 | 5.47 | 6.72 | 8.25 | 8.29 | 7.77 | 6·39 | 6.26 | 5.93 | 5.22 | 5.37 |
| Montgomery | 10.21 | 11.00 | 10.70 | 8.86 | 8.02 | 9.31 | 11.49 | 12.93 | 10.97 | 9·98 | 9·43 | 9.28 | 9.27 | 9.38 | 9.97 |
| Lahore | 21·73 | 21.96 | 2.36 | 19.13 | 16.11 | 16.3 | 15.86 | 18.11 | 17.42 | 19.32 | 18.90 | 13.42 | 16.57 | 17.11 | 18.25 |
| Sialkot | 32.21 | 33.23 | 35.52 | 32.74 | 29.49 | 28.85 | 31·04 | 32·88 | 31.68 | 30.92 | 32.12 | 31·27 | 30.47 | 31.78 | 31.20 |
| Rawalpindi | 34·28 | 35·02 | 36.12 | 34.56 | 31.18 | 33.16 | 34.34 | 38.72 | 39.79 | 38.72 | 37.19 | 38.29 | 38.09 | 39·50 | 37.26 |
| Peshawar | 28.35 | 17.23 | 13.61 | 12.81 | 13.25 | 13.38 | 14.21 | 14·81 | 13·90 | 13·82 | 13.75 | 13.45 | 12.58 | 11·35 | 10.42 |

Table 23 showing the Decennial Averages of Annual Rainfall

| Station | 1871-80 | 1881-90 | 1891-1900 | 1901-10 | 1911-20 | 1921-30 | 1931-40 | 1941-50 |
|---|---|---|---|---|---|---|---|---|
| Karachi | 6.56 | 7.44 | 8.39 | 7.28 | 6.79 | 8.33 | 8.16 | 7.95 |
| Quetta | — | 10.19 | 10.82 | 8.32 | 9·10 | 7.77 | 9.23 | 8.66 |
| Multan | 7.09 | 6.55 | 7.80 | 5.72 | 9.07 | 6.95 | 5.80 | 4.66 |
| Montgomery | 9.76 | 10.29 | 8.76 | 11.01 | 11.72 | 9.47 | 8.91 | 9.83 |
| Lahore | 20.06 | 23.28 | 17.94 | 16.82 | 16.57 | 19.39 | 16.79 | 17.83 |
| Sialkot | 33.36 | 33.81 | 33.30 | 32.44 | 30.81 | 31.50 | 33.93 | 30.41 |
| Rawalpindi | 34.47 | 35.52 | 33.28 | 35.11 | 36.45 | 38.02 | 37.64 | 39·38 |
| Peshawar | 20.43 | 12.55 | 13.77 | 14.17 | 14.15 | 13.58 | 13.30 | 10.77 |

Table 24 showing the Integrated Decennial Averages of Annual Rainfall

| Station | 1871-1900 | 1881-1910 | 1891-1920 | 1901-1930 | 1911-1940 | 1921-1950 | 1931-1955] |
|---|---|---|---|---|---|---|---|
| Karachi | 7.46 | 7.70 | 7.48 | 7.46 | 7.42 | 8.14 | 7.64 |
| Quetta | 10·50 | 9.78 | 9.41 | 8.39 | 8.70 | 8.55 | 8.48 |
| Multan | 7·15 | 6.69 | 7.53 | 7.25 | 7.27 | 5.80 | 5.75 |
| Montgomery | 9.60 | 10.02 | 10.49 | 10.06 | 10.03 | 9.40 | 9.66 |
| Lahore | 20.09 | 10.35 | 17.11 | 17.59 | 17.58 | 18.00 | 17.56 |
| Sialkot | 32.49 | 32.18 | 31.18 | 31.58 | 32.08 | 31.94 | 32.37 |
| Rawalpindi | 34.42 | 34.63 | 34·94 | 36.52 | 37.37 | 38.34 | 36.68 |
| Peshawar | 15.58 | 13.49 | 14.03 | 13.93 | 13.67 | 12.55 | 11.23 |

Table 25 Showing the 30-year Averages of Annual Rainfall & Departure from the Normal Calculated for the Period 1871—1955.

| Station | 1871-1900 | | 1901-1930 | | 1931-1955 | |
|---|---|---|---|---|---|---|
| | Actual | Departure | Actual | Departure | Actual | Departure |
| Karachi | 7.46 | —0.14 | 7.46 | —0.14 | 7·64 | +0.04 |
| Quetta | 10.50 | +1.46 | 8.39 | —2.11 | 8.48 | —202 |
| Multan | 7.15 | +0.39 | 7.25 | +0.10 | 5.75 | —1.50 |
| Montgomery | 9.60 | —0.39 | 10.06 | +0.07 | 9.66 | —0.33 |
| Lahore | 20.09 | +0.69 | 17.59 | —1.81 | 17.56 | —1.84 |
| Sialkot | 32.49 | +0.39 | 31.58 | —0.52 | 32.37 | +0.27 |
| Rawalpindi | 34.42 | —1.64 | 36.52 | +0.46 | 36.68 | +0.62 |
| Peshawar | 15.58 | +2.36 | 12.93 | +0.71 | 11.23 | —1.99 |

**Thirty-Year Means**

Table 25 gives the 30-year averages of annual rainfall and departure from the normal calculated for the whole period (1871—1955). The table clearly brings out the anomalies between the internationally accepted standard period (1901—30) and the 30-year periods immediately preceding and following it. Beside many other things the table clearly brings out the insufficiency of 30 years for calculating the climatic normals for the arid and semi-arid zones. Climatic maps of such areas based on normals for the standard period are, therefore, likely to prove inadequate. Hence, the importance of Russell's concept of "Climatic Years" ([58]) in analysing the core and transitional areas of the various climatic regions.

The magnitude of rainfall variations in the 30-year periods is probably best seen by examining the departures. It will be seen that the period 1871—1900 was comparatively 'wet' in the country except along the Arabian Sea Coast and the Himalayas. The standard period 1901—1930 witnessed a good deal of decrease of precipitation especially in the Divisions of Hyderabad, Quetta, Kalat and Lahore whereas it was above the mean in the Multan, Rawalpindi and Peshawar Divisions. The period 1931—1955 recorded deterioration of precipitation over large areas of the country.

**SUMMARY :**

(1) The polynomial analysis shows that the annual precipitation during the interval 1871—1955 has been decreasing at Quetta, Multan, Lahore, Sialkot and Peshawar at the yearly rate of 0.024, 0.022, 0.030, 0.011 and 0.040 inches respectively. Karachi and Rawalpindi show an increase of rainfall amounting to 0.014 and 0.053 inches per year. The rainfall at Montgomery has been fairly stable.

(2) The polynomial analysis further shows that the rainfall during the interval 1871—1913 was decreasing at Quetta, Multan, Lahore, Sialkot and Peshawar at an yearly rate of 0.053, 0.023, 0.100, 0.071 and 0.030 inches respectively. At Karachi, Montgomery and 'Pindi, it was increasing at an annual rate of 0.026, 0.039 and 0.009 inches respectively during the same interval. The polynomial analysis of the rainfall for the period 1914—55 shows important decreasing trend. Except at Karachi, Quetta and Sialkot where rainfall shows slight increase, it has been decreasing at a high rate over all other stations being investigated in the present study. The annual rate of decrease has been 0.070″ at Multan 0.024″ at Montgomery, 0.021″ at Lahore, 0.052″ at Rawalpindi and 0.124″ at Peshawar.

(3) The periodogram analysis has revealed certain periodicities and some of them are statistically significant.

(4) The moving averages, pentad, decennial and 30-year means show that a considerable deterioration of rainfall has taken place during the last half-century in the arid and semi-arid zones of West Pakistan.

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# SERICULTURE IN RAJSHAHI

By

**SIRAJUL AREFIN**

*Rajshahi University, Rajshahi*

Sericulture is an old industry of Rajshahi. It reached a very flourishing stage as a result of the keen interest taken in it by the Dutch and the English traders, and by the eighteenth century "the district was emporium of the silk trade with a large export, and lucrative mulberry plantations covered a large area".[1] The industry greatly declined in subsequent times due to foreign competition and was reduced to an insignificant position. After Independence it assumed a new importance in the changed economy and is making steady progress since then. As one of the important cottage industries of East Pakistan, sericulture occupies a significant position in the economy of the Rajshahi district, which accounts for almost the entire silk output of the province.

**Historical background :—**

Early accounts about sericulture in Rajshahi are scattered and obscure. But it was definitely an important industry here at least as early as the rule of the last Hindu dynasty of Gour (12th century) when silk clothes used to be exported to important places like Dacca and other trade centres.[2] The real development of the silk industry, however, took place after the advent of the Western traders when the Dutch first organised the export trade of silk in the early seventeenth century.[3] Subsequently the East India Company took keen interest in silk trade and made vigorous efforts to develop the Bengal silk industry. The French revolution and the Napoleonic wars which led to the suspension of the export of European silk to England, and the pebrine disease which ravaged the European sericulture during the mid-nineteenth century, gave great impetus to the silk industry of Bengal. During this time large reeling factories and important trading centres were established by the Dutch and English in the Rajshahi district, mostly along the bank of Padma because of the convenient river communication, proximity to cocoon rearing areas and cheap labour. Cocoons also used to be brought there from Malda district for reeling mainly because of cheap labour supply.

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1. O'malley : Bengal District Gazetteer, Rajshahi, p. 107.
2. Lambourn : Bengal District Gazetteer, Malda, p. 59.
3. Oriental Geographer : Vol. III, No. I, p. 39.

The silk industry of Rajshahi, however, along with that of the province as a whole, began to decline towards the close of the last century. The total annual out-turn of raw silk in the district fell from 400,000 lbs. in 1871 to 97,000 lbs in 1900. In 1911 the total production of raw silk was 22,000 lbs. only and a few years later it fell to a very negligible quantity. The main reason for this decline was foreign competition, specially from Japan. Diseases among the silkworms also caused damage to the industry and the farmers turned to the more remunerative crop of jute,[2] which began to be cultivated on a large scale in the province from 1865 onward.[3] The area under jute in the Rajshahi district rose from 47,000 acres in 1872 to 121,500 acres in 1914-15.[4] This rapid expansion of jute cultivation had apparently an accelerating effect on the decline of the silk industry. On the other hand, an adverse effect on the industry was also produced by the prevalent practice of assessing higher rents on mulberry lands even after mulberry had ceased to be a very lucrative crop. The result was that cultivators were forced to abandon mulberry cultivation and in many cases mulberry lands were converted into mustard fields and pan plantations.[1]

The decline of the silk industry continued throughout the present century and on the eve of Independence it came almost on the verge of extinction in the Rajshahi district. Of course, after partition of the former province of Bengal, a portion of the silk growing area of the district of Malda was added to this district, but the industry there too was cut off from its main centre and was left disorganised. It suffered a further setback as a result of the subsequent migration of many sericulturists and weavers who were mostly Hindus. Since then however, considerable increase in production has been recorded in recent years and intensive official efforts are being made to revive and expand this traditional industry of the district.

**Sericulture and Mulberry cultivation :—**

The rearing of silkworm is necessarily associated with the culture of the mulberry plant because the fresh mulberry leaves are the only food of the domesticated worms. Mulberry cultivation is therefore not only an integral part of sericulture, but is indeed the very basis of it.

**Cultivation :** The mulberry plant cultivated in the Rajshahi district belongs to the species Morus indica (Family, urticacae). The plant thrives in tropical or sub-tropical climates with a moderate rainfall and an average temperature of about 80°F or less. A fertile and well drained loamy soil above flood level with the undergound water-table at a moderate depth are the requisite conditions for its healthy growth. Flood-

1. Lambourn : Bengal District Gazetteer, Malda, p. 61.
2. O'malley : Bengal District Gazetteer, Rajshahi, p. 109.
3. Ahmad, Nafis : An Economic Geography of East Pakistan, p. 87.
4. O'malley : Bengal District Gazetteer, Rajshahi, p. 81.

ing or waterlogging injures the plant and renders the leaves unsuitable for feeding the worms. Most of these physical requirements are fulfilled in the mulberry growing areas of the Rajshahi district. Protection from occasional floods and good drainage, however, are ensured, wherever necessary, by building embankments and raising the level of the land by digging ditches around them.

Cultivation of mulberry is practised in two systems, viz, the bush system and the tree system. The bush system is almost universal while the tree system is recently becoming popular. It has been established after experiments that the tree leaf is superior to bush leaf in food value because of its higher protein and mineral contents. Economically, the tree system requires little recurring expenditure for the maintenance of the plantations. Moreover, trees can be conveniently grown in the patches of wastelands that surround every homestead, village, roadside etc. Its cultivation, therefore, can be considerably extended without encroaching upon other croplands.

Mulberry cultivation involves laborious processes and calls for great skill. In the bush system, the plant is propagated from cuttings which are planted in lines 11/2 ft. to 2 ft. apart. The land requires deep ploughing and planting is usually made after the commencement of the monsoon rains. The saplings are pruned after about three months to keep them within a height of about two feet. Mulberry plantations are perennial, and usually yield leaves for more than 30 years. Regular hoeing and weeding are done, and top dressing with tank mud is made for fertilization. Cowdung is applied occasionally, but the generally used manure for mulberry plantations is the decomposed aquatic vegetation obtained from the marshy lands. In Bholahat locality, the most specialised mulberry growing area of Rajshahi, there is a large marshy area, known as the Bhati bil, which is an important source of manure. The decomposed vegetations from this bil, called locally as 'bhod', is extensively used there for manuring mulberry fields.

Picking of mulberry leaves can be made almost throughout the year. But usually there are four major and two secondary crop seasons. The major crop seasons approximately correspond to the months of May, August, November and March. The average harvests of leaves in these seasons from an acre of land are 60 maunds 5000 lbs approx.), 45 maunds (3700 lbs), 30 maunds (2500 lbs) and 20 maunds (1600 lbs) respectively. The secondary crop seasons corresponds to the months of July and October, having a yield of 12—15 maunds in each. The average annual yield of leaves from an acre of land is about 180 maunds. This amount produces on an average about 500 lbs of cocoons which gives about 30 lbs of raw silk.

In the tree system of cultivation, the cuttings are first planted at intervals of 4″ to 5″ inches. After a year when they attain a height of about 6 feet, the saplings

1. District Gazetteer, Rajshahi -- P. 85.

are transplanted at intervals of 12 feet and pruned at the top. Picking of leaves from the trees is started after three years.

**Distribution** : Mulberry cultivation is highly localised in certain limited areas of the district as a result of the influence of some physical, economic and historical factors. The effect of soil and topography is, however, most obvious.

The northern half of the district is occupied by the Pleistocene tract of the Barind which also extends southward in between the river Sib and the Mahananda, almost reaching the bank of the Padma between Godagari and Premtali. The soil of this whole tract is a stiff clay or clayey loam, usually red to yellowish in colour and therefore locally known as 'khiyar'. It is comparatively dry and poor, and is capable of supporting only one crop, viz. transplanted Aman paddy. Mulberry being an exacting perennial crop cannot thrive on the poor soils of the Barind. Similarly another large portion of the district on the east is rendered unsuitable for mulberry because of the marshy and lowlying nature of the land and its clayey soil.

The nature and the level of land surface and soil have limited the extent of the land suitable for mulberry cultivation only to two small tracts of the district viz. (I) the Padma-Mahananda doab lying on the extreme west of the district and comprising of the Bholahat and Sibganj thanas and the western ports of the Nawabganj and Gomastapur thanas, and (2) the riverine tract, representing the level area of the Padma on the south east of the district and comprising of the Boalia, Charghat and Lalpur thanas.

The former area is an alluvial plain surface seemed almost throughout by old river courses. The soil is a fertile silt loam which is specially suited to the mulberry plant. This tract is not only the most important but is practically the only mulberry growing area of the district so far as the present acreage is concerned. More than 97% of the district's mulberry acreage is found here. The concentration of mulberry cultivation and sericulture in this part of the district not only reflects its favourable soil and climate conditions for the mulberry plant, but also offers a good example of geographical inertia. During the general decline of the silk industry, mulberry cultivation fast lost its ground in Rajshahi district, as also elsewhere. But its acreage in the Malda district of pre-Partition Bengal is recorded to have doubled within a period of twenty years at about the beginning of the present century.[1] This increase, however apparently seems to have been compensatory to the recession of mulberry in other areas outside the district and did not continue in subsequent years. But even in the face of decline, sericulture remained a highly specialised industry in Malda, being concenttrated in the southern part of the Padma-Mahananda doab. After Partition, the more

1. Lambourn : Bengal District Gazetteer, Malda—P. 60.
2. Oriental Geographer : Vol. III, No. 1.—p. 38.

important part of this silk growing area went to West Bengal, so that over 80% of the present mulberry acreage of the State is represented by the Malda district alone.[2]

In the Rajshahi district, the concentration of mulberry cultivation is most remarkable in the northern part of the doab comprising of the Bholahat thana which represents more than 80% of the district's acreage. This high concentration of mulberry in Bholahat area is explained partly by tradition and partly by the absence of any other more remunerative cash crop. The cultivation of jute, which favours higher humidity and rainfall and inundated land with constant alluviation, has never been significant there. Mango is an important cash crop but it is less remunerative than mulberry. Moreover the cultivators prefer mulberry because it gives a quick return and yields 5 to 6 crops a year. Mango on the other hand gives but one crop annually. Over and above there is a lot of uncertainty about the crop and failures are usual.

In the remaining part of the Padma-Mahananda doab, about 16% of the district's mulberry acreage are found comparatively wide spread in the Sibganj thana and the western part of Nawabganj thana. A little concentration, however, is noticed in the Ramchandrapur, Maharajpur and Ghorapakhia localities. On the southern part, outside the Padma-Mahananda doab, mulberry cultivation is found only in a small area on the south-eastern riparian tract of the district. The soil in this part is a fertile sandy loam capable of supporting a variety of crops, including jute and sugarcane. Only about 2% of the district's mulberry acreage occurs here in the Mirganj, Bagha and Chatari localities of the Charghat thana. This small acreage of the present however, only represents the remnants of the past when mulberry used to be extensively grown here, as well as in the adjoining thana of Paba, Puthia, Bagmara and Nator on the north, to support a flourishing silk industry.

**Cocoon Production :**

The rearing of silkworm for cocoon production is an important household occupation in the mulberry growing areas of the district and provides additional employment to the farmer and his family. Women and children usually perform the delicate operations of sericulture with great skill which tradition alone could impart to them. Most of mulberry growers also rear silkworms, while some of them sell the leaves to other cocoon rearers.

All the silkworm reared in the Rajshahi district are multivoltine, producing 5 to 6 generations in a year. Five or six harvests of cocoons are raised annually, but there are four major cocoon crops corresponding to the chief mulberry harvests. About half of the total annual production of cocoons is obtained from the worm known as nistari or madrasi (Bombyx craesi) which is more resistant to high temperature and hence reared for hot weather crop. The other half of the cocoon production is obtained from

1. Lembourn : Bengal District Gazetteer, Malda-p. 60.
2. Oriental Geographer : Vol. III, No. 1.-p. 38.

two hybrids, nismo and nistid, which cannot stand high temperature and are therefore reared only for the two cool weather crops, namely those of November and March-April. The crops harvested in these two seasons are superior both in quality and quantity because of more favourable weather conditions, better quality of the worms and better leaf flushes.

**Silk Reeling :—**

Silk reeling has developed as a specialised handicraft in association with sericulture and requires skilled artisans for its performance. It is not necessarily located in the cocoon producing areas or practised by the cocoon rearers. The greatest concentration of silk reeling, which is done with the help of country charkhas, however, is again found in the Bholahat area where about 96% of the district's "ghias" or country reels are operated. Cocoons are also brought to Bholahat for reeling from Sibganj locality. The entire quantity of cocoon produced in Bholahat area are used in reeling without retaining any for seed, because the chances of disease in the seeds produced in such concentrated areas of sericulture are greater. Seeds are usually obtained from Sibganj and Mirganj. The latter locality specialises in seed production and reeling is insignificant there.

**Table showing the position of sericulture in Rajshahi, 1958-59.**

| Circle. 1 | Mulberry Acreage | | | No. of rearing families. | 'Cocoon' prod. in lbs. | | | 'No. of' working ghais | Quantity or cocoon reeled in lbs. | Raw silk prod. in lbs. |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bush | Tree | Total | | Hybrids. | Nistari | Total | | | |
| Bholahat Circle. | 1088 | 330 | 1,418 | 2,856 | 299,230m | 230,174 | 529,405 | 866 | 525,948 | 46.742 |
| Ramchandrapur Circle. | 173 | 108 | 281 | 335 | 24,764 | 24,846 | 49,610 | 24 | 28,792 | 2,132 |
| Mirganj and Chatari Circle. | 5 | 34 | 39 | in significant | N. A. | N. A. | 20546 | In significant | In significant. | In significant. |
| Total | 1266 | 472 | 1738 | | | | | | | |

(Source :- Department of Sericulture, Govt. of East Pakistan)

**Marketing :—**

More than 70% of the raw silk produced in the Rajshahi district finds its market in West Pakistan where it is in considerable demand for use in various knitting and embroidery works. In East Pakistan silk is mostly consumed by the weaving industry. About 10—12% of the total silk output goes to the weaving centres like Tangail, Dacca and Chittagong in the eastern part of the province, while the remainder is consumed by the local weaving industry which is concentrated in Sibganj area. The main reason for

1 Administrative Circle of Sericulture Department.

the limited market of raw silk in East Pakistan is its poor quality. Silk reeled by country charkha is usually coarser and not uniform, and is unsuitable for weaving saris or other finer fabrics which alone are in demand here.

There is no organised market for the cocoons. The reelers purchase the cocoons directly from the rearers or the petty dealers collect them from the villages. The chief marketing centre of cocoon is Bholahat. Raw silk is also mostly collected from the reelers by the agents of dealers. Purchases are usually made through the middlemen who are considered as experts in assessing the quality of the products. Silk is marketted mostly through Nawabganj and Sibganj.

*Conclusion :—*

The district of Rajshahi is favourably endowed in respect of the two basic prerequisites for successful sericulture, viz. suitable soil and climatic conditions, and skilled artisans. The future development of the industry indeed depends on the scientific utilization of these advantageous factors. The fact that the cultivation of mulberry tree and the rearing of silk worms can be easily carried on in small holdings without the need of any substantial capital also makes sericulture the most convenient industry for the farmers of this area. Usually there is no other more remunerative cash crop in the district than mulberry, and after the ban on jute culivation in the whole of Nawabganj and Sadar Sub-Divisions,[1] the need of extending mulberry cultivation and rearing of cocoons becomes all the more greater to ensure a source of cash income to the farmers. The greatest limitations on the development of the industry are the poor quality of the silk fibre and the lack of organised market. Dissemination of scientific knowledge among the farmers about sericulture, introduction of modern reeling and twisting methods and a proper organization of the market, preferably on co-operative basis, would help a great deal towards removing the present limitations and providing a sound basis for the growth and development of the industry.

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1. Dacca Gazette extraordinary part-I dated 10th Feb., 1959.

# The results of arid zone research at the Geophysical Institute, Quetta

by H. I. S. Thirlaway

*Unesco.*

*Note.* The Geophysical Institute was established at Quetta, West Pakistan in 1951, under the authority of the Director of Meteorological Services. For four years Unesco consultants in atmospheric physics (E.M. Fournier d'Albe), geomagnetism (K.A. Wienert) and siesmology (H.I.S. Thirlaway) and trained personnel of the Meteorological Service helped to install the equipment. Unesco supplied about half the equipment and also provided fellowships for training abroad.

In December 1955, scientists of the Meteorological Service took over full responsibility for the work which had been begun in 1951.

In January 1956 Unesco was asked to continue its association with the institute for another five years through a programme of applied geophysics in arid zone research. The following article reviews some of the results of this work and introduces the scientists who have been trained in this field.

**ENVIRONMENT**

The Western Frontier area of West Pakistan was formerly called Baluchistan. Since the unification of the separate provinces of West Pakistan the area of Baluchistan has been divided into two administrative divisions: the Quetta Division in the north and the Kalat Division in the south. The area of the two divisions is approximately 135,000 square miles, a third of the total area of Pakistan. They are bounded on the south by the Arabian Sea, on the east by the Indus valley, on the north by Afghanistan and on the west by Iran. The population within this area is about 1 million. The mean density of population varies widely from a maximum of 25 per square mile in the Quetta area to 1 per square mile in the Chaghi and Kharan areas which border Afghanistan and Iran respectively. Nearly half the population live in or near the towns and large villages of Quetta, Sibi, Loralai, Fort Sandeman, Chaman, Kalat, Bela, Mastung, Pishin, Khuzdar and Turbat. Of these Quetta is by far the largest with a population of about 80,000. (These figures may be compared with those of the adjacent Indus valley, where, in an area only 70,000 square miles larger, there are nearly 40 million people, and three cities of nearly a million or more inhabitants.)

Average rainfall varies from very nearly zero in the Kharan basin to 18 inches in parts of the Nari basin. Quetta has an average of about 9.75 inches. Temperatures are extreme. Diurnal variations of 40—30°F are experienced in the upland areas with lowest minimum temperatures several degrees below zero, while in the plains the highest maximum temperatures reach 127°F. A local proverb remarks on the superfluity of hell in such conditions. In the west there are large areas of sandy and stony wastes while in the north-east grassy plains and juniper forested limestone hills are common.

Twelve river basins originate within Baluchistan. Two of these are interior drainage areas, namely the Kharan basin of 35,000 square miles, and the Pishin basin of 15,000 square miles. Quetta is situated in the Pishin basin.

Four basins drain south into the Arabian Sea: the Ketch, 10,000 square miles; the Hingel, 17,000 square miles; the Porali, 7,000 square miles; and the Hab, 5,000 square miles.

The Zhob basin, of 6,000 square miles in the far north of the territory is part of the Indus valley system.

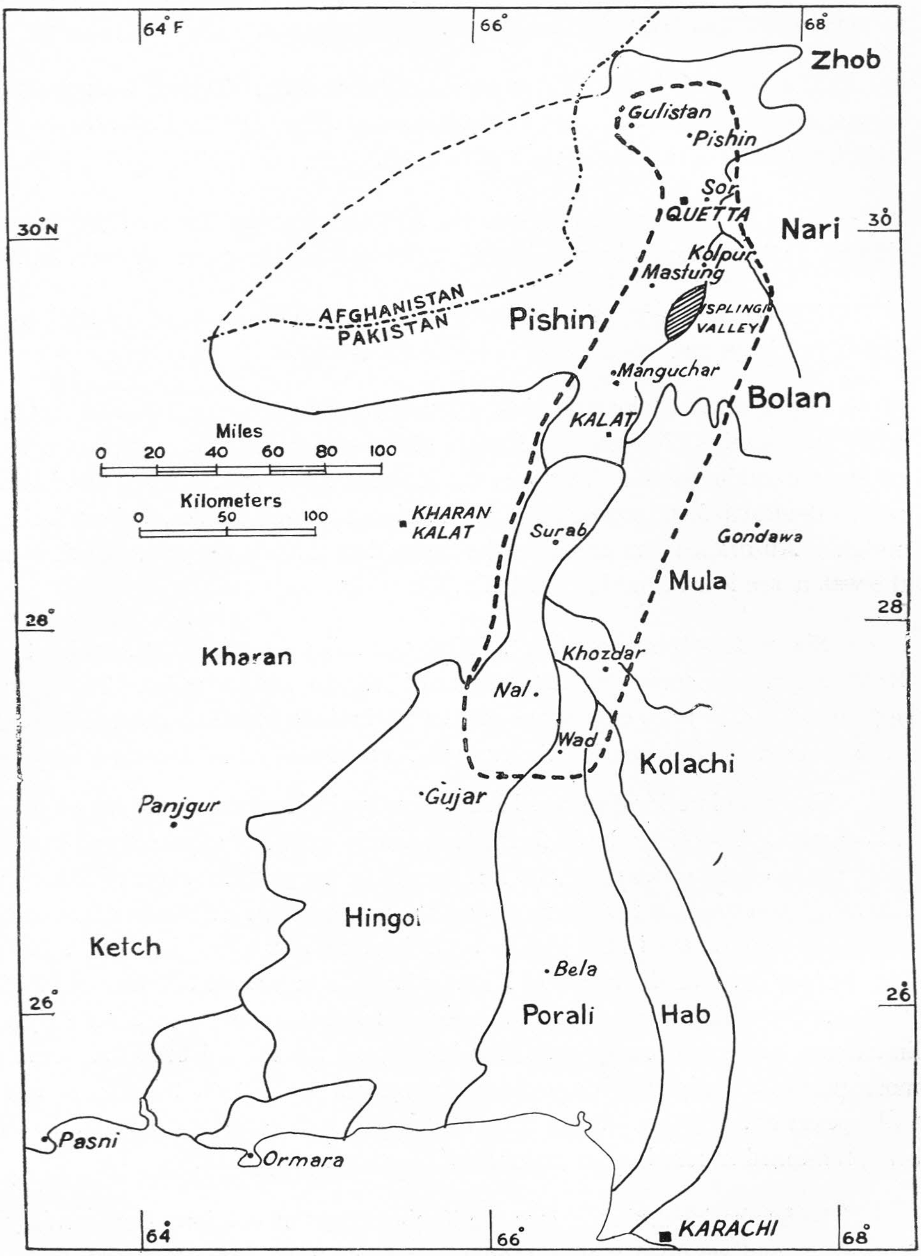
The last five basins drain into a low-lying plain between 200—400 feet high and about 6,000 square miles, in area—the Kachhi Plain—which forms a re-entrant valley on the curve of the mountain system. These are the Kolachi, 3,000 square miles, the Mula 5,500 square miles, the Bolan 3,000 square miles, the Nari 10,500 square miles, and the Lahri 5,000 square miles. All drain ultimately into the Indus, but there is no perennial flow into this river; the waters are lost in the Kachhi Plain.

Six small systems totalling 7,000 square miles drain into the Arabian Sea south of the Ketch basin, and complete the total area of 135,000 square miles. The figures given are approximate and refer only to the area of the basins within Baluchistan. Large areas of both the Kharan and Pishin basins, for example, enter Iran and Afghanistan respectively.

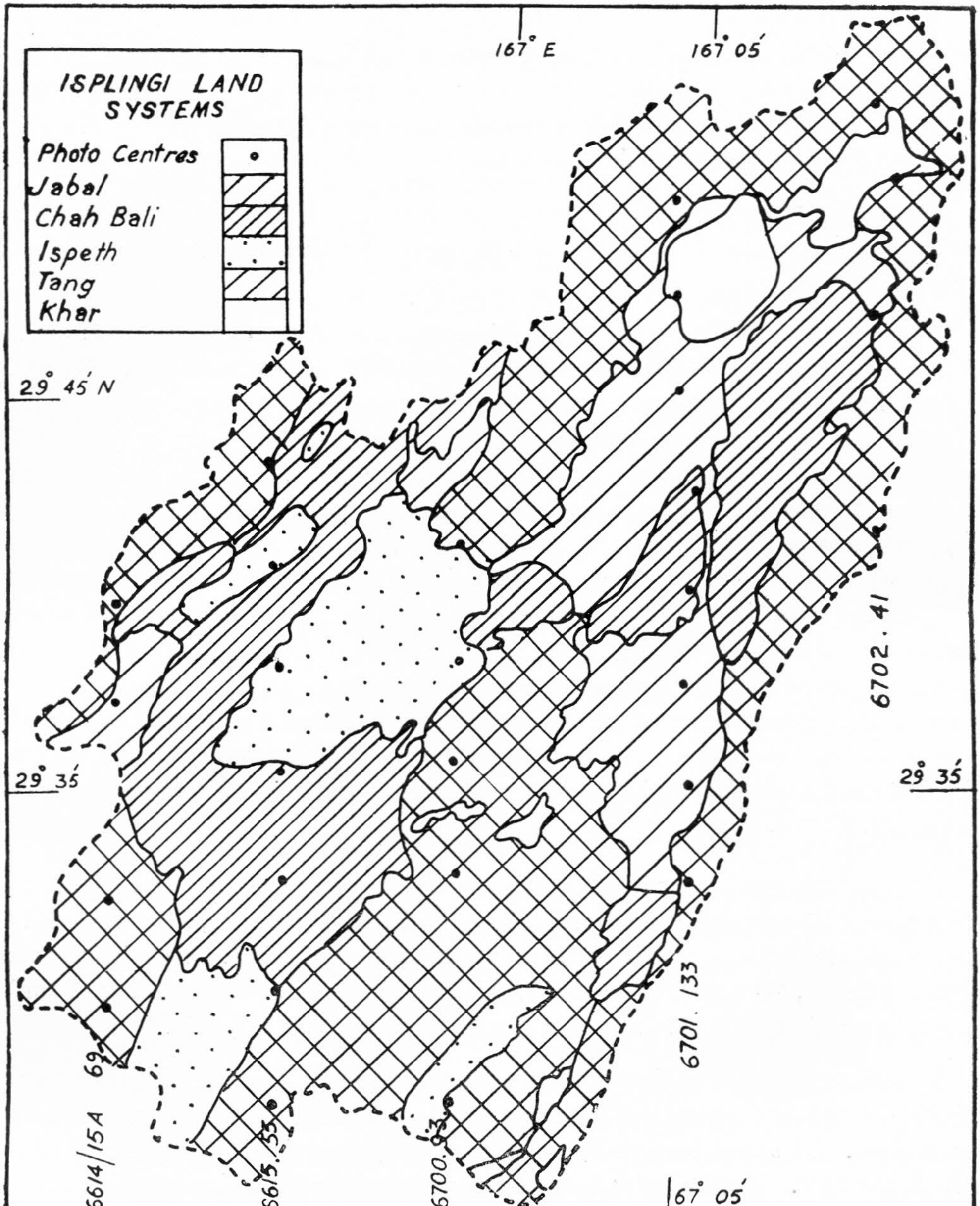
The two interior drainage basins show typical features of the geographical cycle in an arid climate. The Pishin basin formed in recently uplifted limestones and shales, with mountain peaks of the order of 10,000 feet, is still in the youthful stage of this cycle, while the Kharan basin presents for the most part the mature stage with indications of old age. The basins of aggradation in the Pishin basin have an altitude of between 5,000 to 6,000 feet The general level of the plains of Kharan basin is between 1,500 feet and 2,000 feet. The Porali and the Hab basins are developed in mountain ranges of Secondary and Tertiary limestones and sandstones, while the Ketch and the Hingal basins are developed for the most part in a lowlying tertiary mountain system of shales, mudstones and sandstones with peaks of 5,000 feet. Since these four basins have exterior drainage, the land forms are being fashioned in relation to the normal base level of erosion.

The five basins draining into the Kachhi Plain all originate in secondary and tertiary limestones and sandstones with mountain peaks of the order of 10,000 feet and plains of aggradation between 2,000 and 5,000 feet in height.

In outline, this is the area in which the arid zone research of the Geophysical Institute is being developed.




*Sketch map of part of Baluchistan showing the boundaries of some of the river basins named in the text, Isplingi Valley, and the area (enclosed by the heavy dotted line), over which the results of Isplingi may be extrapolated, with the use of air photos and a single main road traverse.*




*Map showing the distribution and areas of the 5 Land Systems of Isplingi. These Land Systems can also be identified within the area demarcated by the heavy dotted line in the sketch map of part of Baluchistan. The code numbers identify the Flight Lines and the serial numbers of the southern-most photograph in each line. The serial numbers increase consecutively to the north.*

## GROUND WATER

About 16,000 square miles (12 per cent) of Baluchistan can be cultivated and about half could be developed as range land. Of the area which can be cultivated only 6,000 square miles are under cultivation, and of this in an average year only 20 per cent or about 1,200 square miles (800,000 acres) is in fact cultivated.

One of the reasons for this is a shortage of developed water supply for irrigation. Water shortage is also one of the factors inhibiting economic development of the range lands. The present position is as follows.

There are roughly between 4 and 5 million acres-feet of stream flow and 2½ million acres-feet of ground water available per year, i.e., a total 7½ million acres-feet. To develop fully the valleys and the range lands, about 25 million acres-feet of water per year are required This estimate is based on the assumption that 17 million acres-feet would be used for food crops and 8 million acres-feet for range lands and fodder crops. It may be possible to meet part of the deficiency of 17 million acres-feet by damming the flood waters in the river basins. This method may be fruitful in the Ketch basin, where shales and mudstones inhibit percolation and cause early run-off during rains, and also in the Zhob and Nari basins where summer rainfall, though equal in quantity to the winter rainfall, is more intense and has a run-off coefficient of between 70 and 90 per cent. Elsewhere in the territory gentle winter rainfall predominates and run-off coefficients average only 5 per cent. In the majority of the territory therefore, recovery of ground water will be more fruitful then damming of surface water, and, incidentally, this method will prevent the enormous evaporation losses which have been observed at the Geophysical Institute to average nearly 6 feet per year reduced to an open water surface.

At present, ground water is utilized through springs, karezes and wells. Tube wells exist only in the Quetta area and at some railway stations. There are 1,800 springs and 600 karezes used in Baluchistan to irrigate 470 square miles (400,000 acres). Wells irrigate about 11 square miles (7,000 acres). About 100,000 acres are irrigated by spreading of surface flow and the remaining 400,000 acres of cultivated land are watered by rain.

The karezes and spring flow without control throughout the year and it is estimated that lining of the flow channels and suitable control would increase the existing supply by a factor of three. This work is currently being executed by the Irrigation Section of the Public Works Department. The Irrigation Section is also responsible for the investigation of unutilized ground water resources by percussion drilling. The Arid Zone Research Laboratory of the Geophysical Institute in co-operation with the Geological Survey of Pakistan have developed methods for efficient siting of the test drills.

### Gravity Methods

The recoverable ground water is stored in the materials forming the plains of aggradation. These materials are invariably less dense than the materials of the mountain ranges from which they were formed. In the limestone areas for example, the density differential is of the order of 0.4 gramme per cubic centimetre. Gravity surveys are therefore proving very successful in demonstrating that the material collected in the basins of the Pishin Basin is between 2,000 feet and 4,000 feet thick and that the basins are bounded by faults. In basins where the enclosing rock types are mainly shales, mud-stones and sandstones (the Ketch basin for example), the material in the basins is only of the order of a few hundred feet in thickness and therefore holds less water. The gravity surveys have also distinguished between those basins which have been filled under lake conditions and those formed under river conditions. It has been found that the lake deposits have been consolidated or semi-consolidated by lime-washes from the surrounding hills, while those formed under river conditions remain unconsolidated, extremely porous, and full of water.

Worden gravity meters have been used for this work and height control has been made by combination of geodetic bench mark, railway bench and micro-barograph. Inch maps are available for the Quetta Division and half-inch or quarter-inch maps for the Kalat Division. Air photographs of contact scales 1: 40,000 are available for the whole area.

**Seismic Methods**

Seismic refractions have been used to determine the depths and to identity of the layering within the limestone basins. There is usually 10 feet of very low (1,000 feet per second) sound velocity material at the surface followed by dry clay of 3,000 feet per second down to the water table. If the water table is in clay, a velocity between 5,000 and 6,000 feet per second is usual; in unconsolidated limestone gravels the velocity lies between 6,000 and 8,000 feet per second in consolidated gravels (limestone conglomerates) the velocity is between 10,000 and 12,000 feet per second, and in Tertiary shales between 8,000 and 9,000 feet per second.

Seismic reflections have been used to confirm the gravity results for the total thickness of the materials within the basins.

The Pye refraction equipment using Teldeltos paper recording has been found useful in this work. Usually two sets are connected in series to give eight channels. The bulkiness of the amplifiers is a disadvantage which might easily be overcome in these days of miniature valves, transistors and printed circuits. The reflection equipment is the Mid- Western high resolution shallow equipment. Reflections from 100 feet onwards can be obtained with this equipment using air shots.

With two test holes sited according to the geophysical results it is possible to determine the ground water resources of an area of 150 square miles in one month's field work using the gravity and seismic method combined.

**Electrical Resistivity Methods**

The Geological Survey of Pakistan recently completed a surface resistivity survey using the Wenner method at and between the 40 tube wells in the vicinity of Quetta. The interpretation of the depth curves was controlled by the known strata changes in the bore holes, and the information was interpolated between the bore holes up to distances of about a mile apart. The work identified the position of former fan structures and drainage channels down to a depth of 400 feet.

## POWER

The total electrical power generated in Baluchistan is about 3,000 killowatts of which about 2,500 kilowatts are generated in Quetta. Ground water discovered below 100 feet, in no matter how great a quantity, will be uneconomical to use without a source of cheap power. The cost of power in Quetta today is 5.6 U.S. cents per kilowatt-hour. Transmissi on distances are large, so that low cost electrical energy from the hydro-electric sources in the far north of West Pakistan are unlikely to reach Baluchistan. The alternative is to use isolated thermal power stations with local coal, wind power and/or solar energy.

### Coal.

The coalfields of Baluchistan are found in Tertiary rocks in the Pishin basin near Quetta. There are three fields; (a) Sor Range, nearest to Quetta, with reserves estimated to be not greater than 50 million tons, up to a depth of 3,000 feet; (b) the Mach coalfields 45 miles south of Quetta, the reserve have not yet been calculated, but possibly are of the same order of magnitude as (a); (c) the Shahrig coalfield about 100 road miles east of Quetta, the resources are not known precisely, but they are several times those of the Sor Range.

The average calorific value of the coal is 10,000 British Thermal Units per pound. Coking is generally difficult and the sulphur and ash content is generally high. The production in 1956 was about half a million tons. About 1.3 million tons of coal was imported in the same year, at a consumer cost of between Rs. 60 and Rs. 100 a ton compared with Rs. 50 to Rs. 60 a ton for local coal. The Planning Board have estimaed that each rupee invested in the production of local coal saves more than 1 rupee of foreign exchange each year.

To prepare the way for this investment, a detailed geological survey of the coal fields was started two years ago by the Geological Survey of Pakistan. The Arid Zone Research Section of the Geophysical Institute was invited to contribute, and advantage was taken of the facilities provided in the field by the Geological Survey of Pakistan to make a thorough investigation of the use of shallow reflection work in the steeply dipping environment of the Sor Range coalfield. There were two main difficulties: (a) obtaining reflections without the use of shot holes, and (b) determination of the reflection point on horizons dipping up to a maximum of 50 degrees.

The first difficulty was solved by the use of air shots detonated at a height of about 5 feet, above ground. Two simultaneous shots gave a very large increase in reflection quality compared with one shot. The use of two geophones to each channel in place of one also enhanced the reflection quality, though to a lesser degree than the two simultaneous air shots.

The second difficulty was solved only by the use of geological control. In other words the method is useful in high dips for confirming observed dips, and for detecting a systematic change of dip with depth.

Gravity has also been used on the Sor Range to determine the boundary fault of the coalfield under Pleistocene cover .

**Wind.**

Wind energy surveys have been completed at two points in the Pishin basin and are currently under execution in the Kharan and Zhob basins. The wind energy available at Karachi airport (south coast environment) has also been analysed.

In the Pishin basin, given a windmill with a wheel of 18 feet in diameter and a depth of water of 100 feet, a total of between 1,000 and 5,000 gallons (depending on siting) of water a day can be pumped to the surface. In Karachi the mean daily capacity of a windmill under similar conditions is 20,000 gallons. In terms of electrical power, a site near Karachi airport could deliver an annual output of 65,000 kilowatt-hours using a 50-foot diameter propeller-type rotor with a rated speed of 15 miles an hour and a cut-in speed 10 miles an hour. The conclusion is that Pishin basin windmills could conveniently pump village water, irrigate small gardens, and water large herds of stock in the range lands. Near the outlet of the Hab River basin, a suitable market garden area for Karachi, suitably chosen windmills could each irrigate about 6 acres a day with an inch of water.

**Solar Energy**

No systematic applied work on solar energy has been completed at the Geophysical Institute. Several years of continuous records of the amount of solar engery arriving at Quetta have been analysed, and there is clearly an abundance of energy waiting to be put to use in the Pishin basin. Other areas of Baluchistan are likely to be equally favourable.

**INTEGRATED SURVEYS**

Once water and power have been found, how are they to be used? The great majority of the 1 million inhabitants of Baluchistan are nomadic to some degree; even Quetta's population is reduced by 25 per cent in the winter. Each winter, nomads from Afghanistan pour down the Baluchistan passes filling the trunk roads with colourful processions of people, camels and stock. Black goatskin tents set against stony wastes are common sights in spring and autumn on the trade routes through Baluchistan.

There is an evident need for surveys to determine both ways of using the 135,00 square miles of Baluchistan, and ways of persuading its nomadic inhabitants to use land in the best way.

At present the land is for the most part used as uncontrolled pasture for sheep and goats. There are comparatively small and low yielding areas of wheat, maize, half of which depend on rain falling at the right time and in sufficient quantity for a successful harvest. Potatoes, onions, tobacco and fruit are irrigated each crops (chiefly from the pishin basin) which are marketed in Karachi. Dates are the staple diet in the Ketch basin. The area as a whole is deficient in food, and does not earn its keep. Little fodder is grown, and sheep and goats begin grazing in the upland valleys as the spring shoots begin to show. Stock are watered from natural sources though wells are used in some areas, the Planning Commission[1] has this to say about the area:—

"The extreme paucity in this region of basic data, essential for projecting all water resources development, is demonstrated by the schemes which have been abandoned, or have ended in failure in the past. Much more detailed and precise knowledge of the hydrological, geological and other conditions of the region is needed to avoid the recurrence of such mistakes. The first requirements are a comprehensive survey of the water resources, topography, soils, land use and the economic needs to be served by water and power resource development, and a logical and consistent general plan for the purpose, for which a sum of Rs. 3 million has been provided in the plan."

It has been suggested that the quickest way of mapping this information is by integrated surveys on the lines developed by the Division of land Research and Regional Survey of the Australian Council of Scientific and Industrial Research. This is a form of land survey aimed at obtaining a synthesis of basic facts on a broad scale in a short time over large areas. In applying the method to Baluchistan the object is to provide a basis for a sound development policy in primary industry. There are two basic problems : (a) to describe and map 135,00 square miles (1/3 of Pakistan) within 5 years; (b) to synthesis the surveys in terms of land use potential.

The conventional surveys of geology, soil, vegetation, climate, hydrology, etc. are too slow, and do not lead automatically to a synthesis, particularly as these surveys are the responsibility of a different Government departments each producing its own and separate map. A more fundamental approach to land classification is via *complex* of factors which have given the land surface its existing shape and texture. These are:

(*a*) the rocks (geology)

(*b*) the processes which have shaped the rocks (geomorphology)

(*c*) the soils derived from the rocks (pedology)

(*d*) the natural vegetation as adapted to environment of topography, water table, soils, and climate (plant ecology).

**Integrated Survey of Isplingi.**

The integrated survey field unit based for a month last summer (1959) at the Geophysical Institute therefore consisted of a geologist, geomorphologist, pedologist and plant ecologist supported as required by a climatologist and a groundwater geophysicist. Isplingi

1 National Planning Board of Pakistan, First Five Year Plan 1955-1960,1957, P. 388,Para 161.

valley was selected for the demonstration on the previous recommendation of Mr. R.E.G. Cunningham of the Food and Agricultural Organisation. This valley is situated some 10 miles south of Kolpur (at the head of the Bolan Pass) and lies between the Bolan Pass and Mastung Valley. Mr. Mashar Aslam has this to say on the valley:

"Isplingi valley is an enclosed drainage area of about 250 square miles. There are three major population centres, Isplingi, Marov, and Talkh-Kavi, inhabited by the two main tribal groups, Bangulzai and Kurds. The population of the area is more than three thousand, more than 12 per square mile. The avergae for the Quetta area is 25 per square mile.

As life depends on water, large sections of the population settled down around the wells in Isplingi and Talkh-Kavi villages or near the Karez in Sardar Khail village. Those who do not get their food by working the soil, concentrate on "Free Range" stock raising, pasturing their camels, sheep, goats, cattle, horses and asses, on the desert vegetation and on the widely scattered, and short lived, grazings which flourish briefly when and wherever a shower chances to fall. This keeps the people moving. In winter the whole population moves down to the Kachi Plains with their families and herds, leaving very few people in the valley. People move because weather gets severe after October and during winter they have nothing to do. They sow their fields before the onset of winter. The people, being very poor, cannot afford warm clothing. Firewood in the area is also scarce. It can only be obtained from the area about 10 miles south of Isplingi village.

The whole valley is joint property. There are very few cases in which fields or gardens are worked by their owners independently. The people are very poor and they cannot afford to invest in wells, Persian Wheels and camels to drive them. The group property system has also lessened the interest of the people in the development of the area. Every partner tries to get the maximum benefit out of idle lands and pastures with the minimum of labour investment. In these areas, people also destroy trees, wild plants and even roots for fuel. This long-continued practice has helped to make pasture very scarce. Deforestation and over-grazing have affected the soil of the area very adversely. It has dried out, and, having no protection against the winds, serious wind erosion has resulted in loss of the top soil.

If the land of the area is distributed amongst individual owners, it is possible that fear of shortage, and desire for better living conditions, might give rise to an extraordinary development of effort on the part of the individuals.

The agricultural industries, which are mainly confined to the irrigation of crops on the better alluvial soils, cover only a very small area in the valley. Water for irrigation is obtained from shallow wells in Isplingi and from one karez in Sardar Khail. The major crop is wheat, which is only for their own requirements. Vegetables are also grown for local consumption. There are no markets for the sale or purchase of foodstuffs.

Foodstuffs, kerosene oil, sugar, tea, textiles and other manufactured articles, are brought in from Sukkur, Mastung, Kolpur and Quetta. The area is not connected by rail but is served by two fair-weather roads, connecting Isplingi with Mastung, Kolpur and Johan. The nearest railway station is Kolpur, about 15 miles away.

People are illiterate. There are no educational facilities except for one primary school. A whole-time primary school teacher looks after the school and 25 children. In the village of Sardar Khail, one Maulvi imparts religious education to the few boys of the village. This madersah is the rehabilitated, ruined mosque of Sardar Khail.

For the development of the area, an honest and sincere leadership is needed. The present young, educated and intelligent Sardar would seem ideal for the purpose!.

The following description of the survey will illustrate both the main differences from conventional methods, and how the single land classification map is derived from the complex which constitutes a land surface.

Air photographs are essential to the method and we are fortunate in having a full West Pakistan coverage on the scale of 1 : 40,000 completed by Hunting Survey Corporation under a Canadian Colombo Plan project. The Isplingi valley air photos were laid down as a mosaic so that the valley as a whole could be studied. Immediately certain recurring patterns became evident. No attempt is made at this stage to interpret the patterns in terms of the natural complex which cause them, but the patterns are classified and described. The "Old Delft" scanning stereoscope was found exceptionally useful at this stage for running quickly through stereo pairs covering the whole valley. The classification of these air photo patterns can be made as broad or as detailed as the nature of the survey and the time available permits. The smallest unit of classification is called a "Land Unit" after Australian practice.

Variation between Land Units are expressed by changes in topography soil and vegetation. Usually the selected Land Unit is too small to map conveniently, but they are, in the nature of goemorphologic processes, always associated in easily recognisable patterns. These associations of Land Units are called Land Systems. Christian and Stewart (CSIRO) have defined a Land System as "*an area or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation*". The Land Systems are the mapping unit, and after the preliminary classification from the air photo patterns, field traverses are planned to representatively sample each Land System by the geologist, geomorphologist, pedologist and plant ecologist. The survey unit spent a total of 10 days in one base camp during which time they made 500 miles of traverses in the 250 square miles of valley. Navigation was done with the air photos and one inch topographic sheets. Frequent stops were made at selected sites to compile comprehensive records, each scientists collecting his own specialist material. Particular attention was paid to the provisional Land System boundaries identified on the air photos and the reason for the change in pattern recorded in each specialist field. Shorthand symbols are devised for recording information on the air photos, each traverse is plotted, and recognisable boundaries are marked. Meanwhile, a separate climatological and groundwater study of the valley was prepared.

The Integrated Survey Unit then returned to the laboratory and each scientists synthesised his own data, re-examined the air photographs, extended the detailed interpretation over the whole area, modified the preliminary Land System boundaries as necessary, and prepared the Land System map on a base map constructed by radial centre plotting from the air photographs.

The reduced Isplingi Land System map and the synthesised description of the Land Systems of Isplingi, prepared by Mr. Mazhar Aslam, now follows.[1] 'The *beginning* of each air photo run has been numbered, and each photo centre marked for the convenience of those who may wish to study a whole or part of the area in detail.

**The Jabal System (62,000 acres).**

This Land System comprises the rugged limestone highlands (almost entirely bare of vegetation) and their foothills. It has the largest area of any single system in the valley.

Mountain peaks increase in height from about 7,000 ft. in the north, to 9,000 ft. in the south of the valley. In common with most of the northern Baluchistan area this increase in altitude is accompanied by a climatic change which allows the growth of Juniper forests. Rainfall at this level must average about 12″ per annum, reducing to anywhere between 6″ to 8″ over the remainder of the Jabal and the other four systems. It is thought that this rain is almost equally divided between winter and summer with, perhaps, a preponderance of winter rain. Light snow lies on the peaks from December to March. Much of this snow is thought to be lost by direct evaporation.

The great potential importance of the Juniper highlands (though small—about 25 square miles), has led one of our colleagues to suggest placing them in a separate Land System. In this report they are identified as a separate Land Unit. When the much greater areas of this type are studied in the remainder of northern Baluchistan, it may well be more convenient to include them in a system of their own.

The geology of the System is massive, grey, Jurrasic limestone, steeply folded. Dip slopes are almost everywhere predominant. At the foot of the hills are well developed alluvial fans deeply dissected by nullahs in which the vegetation is clearly more abundant.

| | | | | |
|---|---|---|---|---|
| Relative areas of Land Units | Small | Very large | Very small | Small |

| | | | | |
|---|---|---|---|---|
| Topography | Steep hills 8,000 ft. | 8,000 ft. | Steep colluvial slopes | Alluvial slopes cut by nullahs |
| Vegetation | Juniper | Astragalus — Ebenus Artemisia Occasional grass | Astragalus — | Mixed Frequent grass |
| Soils | Skeletal .. limestone lithosol | Stony soil of moderate depth | stony or very gravelly, of good depth. | |
| | | Shishar and Baluchistan Series. | | |
| Drainage | Good | Excessive | | Good to excesive |
| Ground Water | Two or three small springs at foot of steep slopes. | | | |

**Ispeth System (22,000 acres).**

This system also has a preponderance of rugged, steepsloped highlands reaching a maximum of about 8,000 ft. The only difference between this and the Jabal System lies in the geology. Ispeth System rocks are mainly of Cretaceous age, comprising thin bedded cream coloured limestones (Ispeth: Brahui—white)—the Parh limestones—and green and red coloured shales—the Belemnite Shales. The Dunghan limestones, Eocene age, is also present. These rocks have been faulted against the Jurassic limestones.

The presence of shale in this system leads to better soils and moisture retaining conditions, and so in turn to about twice the vegetative cover of that in the lower (northern) Jabal System.

| Relative areas of Land Units | Large | Medium |
|---|---|---|
| Topography | High Steep Hills | Colluvial and Alluvial slopes |
| Vegetation | Astragalus with Artemisia | Artemisia with Acanthophyllum |
| | Occasional grass | |

| | | |
|---|---|---|
| Soil | Skeletal limestone and shale lithosol | Gravelly soil with high content of silty material. |
| Drainage | Excessive | Good to excessive |
| Ground Water | No significant resources | |

**Chah Bali System (46,000 acres).**

This system lies at a much lower level (5,500 ft. 6,000 ft.) than the previous two highland systems, and is almost entirely composed of debris from the two highland systems. The age of the debris varies from Pleistocene to Recent. Pleistocene deposits form low rolling hills merging into the gently sloping later deposits which end with a change of slope at the foot of the alluvial fans of the Jabal and Ispeth Systems.

| | | |
|---|---|---|
| Relative areas of Land Units | Medium | Medium |
| Topography | Rolling hills | Gently sloping |
| Vegetation | Galonia—<br>Ebenus<br>Occasional grass | Artemisia—<br>Haloxylon<br>Very seldom grass |
| Soils | Thin layer of gravel sandy loam underlain by heavy gravel silt (Cash Bali Series) | Gravelly sandy loam over gravelly silt. Loam underlain by gravelly sandy loam (Maro Series) |
| Drainage | Excessive | Good to excessive |
| Ground Water | Below economic depth for irrigation. Possible for stock watering. | |

**Tang System (27,000 acres)**

The Tang differs from the Chah Bali System in altitude (5,000 ft. — 5,500 ft.), coarseness of material, slope and depth of soil. Geomorphologically no boundary between the two systems exists, but from the land use aspect there is a distinct difference, which has already been exploited over many hundreds of years. The difference is compounded of the factors already mentioned; in particular, decreasing slope allows the building of low check dams for sailaba (flood or run-off) cultivation. The Tang System boundary is that of the cultivated area of the valley.

| | | |
|---|---|---|
| Relative areas of Land Units | Medium | Medium |
| Topography | Gently sloping | Very gently sloping of level |
| Vegetation | Fields with weeds from adjoining Chah Bali | Fields with weeds from adjoining Khar |
| Soils | Deep sandy loam or Silty loam (Quetta Series) | Silty clay or Heavy Silty loam (Isplingi Series) |
| Drainage | Good | Fair |
| Ground Water | Within 100 ft. of surface in most places, especially on western half of valley. Good yield. | |

**Khar System (4,000 acres)**

The Khar System comprises the sump of the inland drainage valley. There is no drainage; the surface is very nearly level, and the clay soil provides a tough, smooth surface over which very high speeds can be reached. In wet weather the area is impassable.

| | | |
|---|---|---|
| Relative areas of Land Units, | Small | Large |
| Topography | Very gently sloping | Level plain |
| Vegetation | Haloxylon, Polygonum sp. Haloxylon salicornieum | Alhagi camelorum nil. |
| Soils | Clay or S. Clay over clay; very tough (Khar Series) | |
| Drainage | nil | |
| Ground Water | Within 100 ft. of surface, low yield. Suitable for stock watering only. | |

**Land Use Groups**

Mr. Mohammad Rafiq of the Soil Conservation Service has grouped the Land Systems into the following Land Use Groups:

| Land Systems and areas in acres | Land Use Groups Present | Possible |
|---|---|---|
| Jabal 62,000 | Grazing wherever accessible | Closed watershed controlled timber cutting in parts |
| Ispeth 46,000 | Grazing | Range improvement followed by grazing. |
| Chah Bali 22,000 | Grazing | |
| Khar 4,000 | Grazing | |
| Tang 27,000 | Irrigated cash and fodder crops — 1,000 acres. Fruit, lucerne, potato, onion, | Irrigated cash crops — 3,000 acres. melon, vegetables. |
| | Sailaba food crops about 6,000 acres per wheat, maize, sorghum | Sailaba food and fodder crops 12,000 acres. Grass seeding followed by grazing, 12,000 acres. |

His figures for Poss ble irrigated cash crops are based on the ground water and climatology survey. His reason for devoting half the remaining Tang System to stock (sheep) raising is that under the present methods, $\frac{3}{4}$ of the Tang System lies idle each year. Furthermore, the climatology survey showed that under kushaba methods a successful wheat crop has only 1 chance in 3 years of success. Sailaba methods improve this ratio, but nevertheless, the political department's averages record a failure every 3 or 4 years and it is quite clear that the Tang System, the richest in fertility, is not being used properly. The survey also showed that every part of the Tang System has been in use at one time or anothr and that there is no virgin land for development. Development therefore depends on *change of land use and/or* method.

Irrigation of the whole area is impossible even if pumping power were available and cheap, because groundwater will only develop a total of 3,000 acres on a permanent basis. Elsewhere, in similar climates and environments, such land is used for the raising of sheep. Though Baluchistan has a long pastoral tradition, its traditional range lands in this area are typical of the Chah Bali Land System of Isplingi. For raising sheep on a productive basis, this type of range now needs 150 acres per sheep unit, and can be improved, after many years closure, at best to support one sheep unit per 50 acres[1]. The valley bottom lands characteristic of the Tang System have never been used as range lands within historical times. Their potential is *at least* 5 acres per sheep unit[2], ten times greater than the traditional range lands.

On these figures and results, it is self evident that it would be profitable to use the idle ¾ of the Tang System as range land, and to make the arrangements necessary for *annual* use of the remaining ¼ as sailaba. *This suggestion has the merit that traditional range land* (Cash Bali System) is reserved *for the exclusive use of nomadic pastoralists and powindahs, if any.*

On the Tang System, Mr. Cunningham's advice[3] is to use the groundwater for irrigation by windmill[4] of ½ acres domestic kitchen garden and forage plots, within 1,000 acre fenced units. These will be reduced to 500 acre units as the natural fodder recovers and techniques are learnt. Each unit will carry one family owing 100 sheep. The cost of fencing adjacent plots with imported wire, and local concrete posts will be Rs. 5,000/- and each windmill Rs. 5,000/-. This debt of Rs. 10,000/- can be paid off at the rate of Rs. 400/- per year for 25 years.

Mr. Cunningham estimates the minimum annual income of each unit of 100 sheep as follows :

| | | | |
|---|---|---|---|
| 80 lambs at Rs. 20/- each | .. | = | Rs. 1,600/- |
| 400 lbs wool at Rs. 2/lb. | .. | = | Rs. 800/- |
| | Total. | = | Rs. 2,400/- |

After payment of loans and costs for technical services (e.g. stock medicines Rs. 200/-) the *net* annual income of each family will be Rs. 1,800/- (say Rs 300/- per head)

1. Hoy C. Connelley. Narrative report on the possibilities of economic development Quetta/-Kalat Divisions through proper Range Management, 1960.

2. R.E.G. Cunningham, personal communication.

3. Personal communication.

4. Full records of wind speed in Isplingi are now available for July-October 1959. Each month shows a wind speed 59% greater than for Staff Road Quetta. The power output will therefore be more thau 3 times greater than in Quetta valley. (Naqvi & Aslam in their paper on wind power potential in West Pakistan.) In terms of water this is equivalent to 3,000 gallons/day pumped from 100 ft, by an 18 ft. windmill. That is, one acre per week will be irrigated with 1'. of water.

to compare with an average *gross* over all Pakistan of Rs. 100/- per head per annum. In Isplingi 40 families and 4,000 sheep would ultimately benefit, the total productivity being Rs. 96,000, say Rs. 1 lakh per annum from $\frac{3}{4}$ of the Tang System.

There is nothing in the above quantities which conflicts with the scientific results of the Integrated Survey of Isplingi and the scheme disposes neatly of the nomadic problem since the land concerned is not in any case used by the nomads, and will be fenced. There will even be a surplus of groundwater for gradual development of the existing irrigated land to double its present area after the needs of the range land have been met. An ideal starting point is the southern half of the Tang System in Isplingi where about 7,000 acres are available, and where a line of 4 test holes may be drilled this year by the Investigation Circle of the Irrigation Department.

One difficulty is foreseen. Although neither the existing irrigated land nor the *area* under sailaba cultivation will be altered, nevertheless, the land is presently owned by the community as a whole. On a large part of this land, Mr. Cunningham proposes to settle a maximum of 40 land owning families. It is clear that decisions at a high level will be needed, followed by the application of social science of high quality, and backed up by the closest co-operation between the political, administrative, and technical services.

Cunningham's proposals have been used in this illustration of the use of Integrated Surveys because no other detailed schemes for improved use of the Tang Land System have come to my notice.

It is the purpose of Integrated Surveys to present the facts on which decisions can be based. It is hoped that the decisions will lean heavily on the scientific facts, for the best land of Baluchistan is now largely lying fallow. The total area of the Tang Land System in Baluchistan is about 600,000 acres comprising the valleys, between Quetta and Drakalo, of Quetta, Spezand, Aghbarg, Isplingi, Mastung, Khad Khucha, Mungachar, Kalat,Chhapper, Panjai-Patki, Surab area, Nal, Bhawana, Wad, and Drakalo. On Cunningham's advice and figures, the gross income from the use of 3/4 of this area alone as fenced range land is Rs. 20 lakhs per annum from 1200 families raising 120,000 sheep. Here is the basis of a yeomanry in Baluchistan.[1]

New Integrated Surveys are necessary outside the region of the above valleys since either the geology, or climate, or altitude, or all three, change markedly, and there are likely to be equally marked changes in soils and ecology. Furthermore, the Pathan peoples predominate north of Quetta, and their different social structure will require a different approach to obtain co-operation, and understanding of any change in land use which the surveys show to be necessary. In general however, the valleys north and east of Quetta will be more productive, and those of Mekran and Kharan less productive than those of the Isplingi type[2].

1. See also Hoy C. Connelley, p. 4., oq. cit.

2. See Mazhar Aslam's report. p. 10 of report on Integrated Survey of Isplingi and also in my Annual Report for 1959.

Continued scientific work in two fields is necessary if decisions involving change and development are made as a result of Integrated Surveys.

(*a*) Experimental Stations. If, for example, it is decided to use the Tang Land System as range land, an experimental station must be established in one representative area to experiment with fodder crops, yields, carrying capacities, and diseases.

In this particular example experimental stations already exist. They need only be adapted to serve the one central idea in place of the confusing multiplicity of programmes which reduces efficiency today.

(b) Social Science. There is an unavoidable absence of contact between the local rural people and the administrative and technical officials, who serve in the area for two or three years. All decisions involving land use and de-development in this area finally affect a very conservative group of land owners or land users usually having a different mother tongue to the officials. It seems self evident that it would be useful to have a small department whose duty it is to know, or to study, how best to obtain the maximum co-operation and understanding of these people. Such a research group could become a tremendous asset to the land research and regional survey groups, and to the development departments.

**Acknowledgements.**

The successful outcome of the first integrated survey ever to be attempted in Pakistan, was due to the combined efforts of the following departments:

The Soil Conservation Project, Rawalpindi,
directed by Dr. A.G. Riaz

The Forest Research Institute, Abbottabad,
directed by Mr. A.H. Khan

The Geological Survey of Pakistan, Quetta,
directed by Dr. E.R. Gee

The Pakistan Meteorological Service,
directed by Mr. S.N. Naqvi.

It is noteworthy that the work in Isplingi was carried out by each of these departments as part of their annual programme, without need for extra financial sanction. *Integrated Surveys are not another scheme, but simply an efficient method of focussing existing skills within different departments of Government on to a central problem.* The method has been for many years strongly advocated by Mr. S.N. Naqvi.

The scientists who were responsible for the first demonstration were Messrs Mazhar Aslam, A.H. Khan, Hashim Raza, Mohammad Rafiq, M.S. Ahmad, Gertraud Repp, and Zakauddin.

The writer also gratefully acknowledges the kindness of the Director, Mr. S.N. Naqvi, for permission to summarize the geophysical results of the Arid Zone Research Section. Some of the results are given here prior to formal publication, and for permission to do so thanks are due to Messrs, Mufti, Zakauddin and Siddiqui (gravity results); Farah and Moid-uddin (Seismic reflection results); Naqvi and Aslam (wind power results); Menan Khan and Hashim Raza (electrical resistivity results).

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# NEWS AND NOTES

## 1. GUDU BARRAGE*.

A fifth barrage on the Indus is being erected at Gudu by the Water & Power Development Authority under the First Five Year Plan. The dam will irrigate some 1.5 million acres of virgin land and at the same time ensure year-round water supply to the previous inundation canals. In all, the dam will control 308 million acres in the region of Ghotki, Mirpur Mathelo, Ubauro, Sukkur, Rohri, Jacobabad, Kashmore, Thal, Kandkot, Nasirabad, Garhi Khauro, Sadakot, Shikarpur and Garhi Yasin. Another 0.25 million acres of land in the former Baluchistan is expected to be brought under cultivation during the second phase of the dam. The total area commanded by the barrage will be more than 40,000 square miles including 300 square miles of the former Baluchistan. The region commanded by the dam is expected to double its producation of food grains in a matter of 15 years. The increased production of food grains is estimated at 417,000 tons.

Beside increasing the acreage under foodcrops, the Gudu Barrage will irrigate forests covering more than 0.15 million acres. Other features of the dam are an irrigation lock for boats playing on the Indus and fish ladders to catch the migratory fish.

The dam will cost Rs. 370,500,000. The expected return will be about 4.4% on full development at the end of the 15th year. The Headworks will cost about Rs. 157.8 million . The cost of its four main canals is as follows:—

| | | |
|---|---|---|
| 1. Desert Upper Canal | Rs. | 51.4 Million. |
| 2. Begari Sind Feeder | Rs. | 74.8 ,, |
| 3. Pat Feeder | Rs. | 43.5 ,, |
| 4. Ghotki Feeder | Rs. | 43.0 ,, |

Of the total cost of Rs. 370.5 million, the foreign exchange component is estimated at Rs. 106.6 million. It is estimated that beside many other benefits the increase in food production alone would add about Rs. 100 million every year to the national wealth.

—Mubashir L. Khan

## 2. ARID ZONE RESEARCH IN PAKISTAN.

Arid Zone Research in Pakistan has taken a long step forward after the establishment of the Sub-Committee on the Arid Zone Research in 1956. The sub-Committee consists of

*Source 1. WAPAD Annual Report, June, 1959.
2. The Pakistan Times Sunday Magazine.

19 members representing different departments connected with arid zone research. The major aims and objects of the Sub-Committee are the promotion and coordination of arid zone research, provision of grants-in aid to such research institutes and collaboration with UNESCO and other specialized Agencies. Considerable work has been done during the last four years by various departments which may be briefly stated.

1. **Regional Institute for Arid Zone Research, Quetta-Karachi.** Work is in progress on the following projects.

1.1. **Development of optinum methods of applying geophysical** exploration for locating the under-ground water and for continuous recording of groundwater level.

1.2. **Collection of wind and solar data for the Quetta-Kalat Divisions.** Basic data for larger-scale investment in wind turbines have been obtained. It has been shown that ground-water can be pumped by 18 ft. wind mills for domestic and stock requirements. In the coastal desert energy upto 100,000 Kwts. hrs. can be generated using the wind power machines. These windmills can also irrigate 6 acres of land per day.

1.3. **Integrated Survey.** An experiment based on the methods of Land Research and Regional Survey Department of the A.C.S.I.R. has been started in the Isplingi valley near Quetta*. The utility of such a survey has already been demonstrated to the Pakistan Planning Commission. It is a possibility that these surveys might be extended in due course to other arid areas of the country.

1.4. **Agro-climatology.** The project aims at collecting data on micro and macroclimatic environments for some important crops of the country. Five sub-stations for this purpose have been established in various parts of the country.

1.5. **Climatological Atlas of Pakistan.** Meteorological Service is preparing this atlas in collabration with Food and Agriculture Council.

1.6. **Micro-climatological Course July, 1959.** The course was organized by the Pakistan Meteorological Service in collaboration with UNESCO at the Geophysical Institute, Quetta, for the benefit of the South Asian countries.

2. **Central Irrigation Research Institute, Lahore.** The Institute is mostly concerned with the problems of water-logging and salinity. Considerable work has been done on these topics including some useful methods of reclamation. Similar work is also being done at the Land Reclamation Directorate, Lahore and the Agricultural College, Lyallpur.

3. **Symposium on the Soil Erosion and its Control in the Arid and Semi Arid Zones, November, 1957.**

The symposium which was held at Karachi was jointly sponsored by the Food & Agriculture Council of Pakistan and the UNESCO. More than twenty-five contributions were made on various aspects of the problem.

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*The results of the Survey appear in the present issue of this journal—Editors.

4. **Department of Geography Panjab University, Lahore:**

1. The Department is primarily concerned with the climatological aspects of the arid-zone research. Work is in progress on the following subjects.

4.1. **Chagai-Kharan Reclamation Project.** The project aims at preparing a resource inventory on the lines of a regional survey in order to ascertain the scope of development in this highly arid part of the country. The preliminary report which was prepared by Mubashir L. Khan in early 1957 included discussions on such topics as physiography and geology, climate and vegetation, water balance and water resources, soil conservation and industrial aspects. An enthusiastic plan has been prepared for the second phase and submitted to the Food and Agriculture Council of Pakistan for the provision of a grant.

4.2. **Arid Zone Climatology.** A critical study of the Thornthwaite's system of potential evapo-transpiration is in progress. The variability of various climatic elements is also being studied in context of its effects on the agricultural activities in the marginal areas.

4.3. **List of Publications on the Arid Zones.**

1. Mubashir L. Khan, "Water Balance and Magnitude of Water Deficiency in the Arid Zone of West Pakistan" Pak. Geog. Review, Vol. 12, No. 2, 1957.

2. Kazi S. Ahmad / Mubashir L. Khan, "Variations of Moisture Types and their bearing on Soil erosion in the Arid and semi arid zones of West Pakistan" Pak. Geog.-Rev. Vol. 14, No. 1, 1959.

3. Mubashir L. Khan, "Recent Pluviometric changes in the Arid and semi-arid areas of West Pakistan" Pak. Geog. Rev. Vol. 15 No. 1, 1960.

4. Kazi S. Ahmad / Mubashir L. Khan, "Variability of rainfall and its bearing on the Agriculture in the Arid and semi-arid zones of West Pakistan." To be published in the Pak. Geog.-Rev. Vol. 16, No. 1, 1961.

**Mubashir L. Khan**

## 3. WARSAK DAM PROJECT

Warsak is one of the major projects going to be set up in the former province of N.W.F.P. and is located near the Pak-Afghan broder some 15 miles away from the mouth of the Khyber Pass. The Project is one of Canada's major contribution under the Colombo Plan. The total cost of the project is Rs. 293 million. The project will, on completion by September this year, supply water for irrigation to about 120,000 acres of waste land and provide power to the extent of 240,000 Kwts.

Source : Press Notifications.

Geographically and hydrologically, the position of the Kabul river near a village called 'Warsak' was considered ideal for building the dam. The mountains on either side of the river at this place are closest to each other for harnessing the incoming water with great ease. The dam will be 760 ft. in length and 250 ft. in height, with a base width of 211 and top width of 48 ft. The dam when completed will create a lake or reservoir of an average width of 1,000 ft. up to the Afghan broder, about 26 miles from Warsak.

The main dam is divided into 140 monoliths and 9 bays with a total discharge capacity of 564,000 cusecs. Before starting the work on the dam the river was diverted from the north bank by a 1,700 ft. long diversion tunnel connected to it in a semi-lunar way. The finishing touches will be given by the middle of this year when the 26-mile long lake adjoining the dam will be filled in by 20,000 acre feet of water in a period of six days and the four generators will start producing about 160,000 Kwts of power. The work on this project has taken nearly four years of round the clock labour by about 150 Canadians and 400 Pakistani Engineers and technicians assisted by some 8,000 labourers.

The Warsak Project will serve the dual purpose of providing irrigation to the former N.W.F.P. area and power to a wide area in West Pakistan. The power house, on the right bank of the river below the dam, will have six generating sets of 40,000 Kwts each, but in the initial stages only four generators will be commissioned to provide 160,000 Kwts of energy. For irrigation purpose, the project will provide 2 high level canals to irrigate nearly 120,000 acres of land on both sides of the dam. The water from the reservior will be taken to a high level canal through a 3½ mile long tunnel on the left bank. The gravity from canal will be about 37.6 miles long which will be fed by pumping the water to a height of 160 ft. It will water 46,326 acres of barren land. The left bank canal, with a total length of 18.5 miles will bring 11,000 acres of land under the plough in the Mahmand Tribal area. The crops that will be raised on the irrigated acreage will be food crops, sugar-cane and fruit. The new area is expected to yield annually about 7,000 tons of cash crops and food grains augmenting at the same time the annual nation's income by over 17,000,000 rupees or over 3.5 million dollars.

Beside increasing the crop acreage, the Warsak Propject will also increase the production of electricity by 100 per cent, when the total output reaches 160,000 Kwts. as compared to the present electric consumption of West Pakistan which is about 125,000 Kwts. West Pakistan stands for below when compared with the per capita consumption of electricity to other advanced countries like, Canada, 3,510 Kwts; Norway 3,090 Kwts.; Sweden, 2,000 Kwts; Switzerland, 1,933 Kwts; U.S.A. 1,420 Kwts; England 906 Kwts. The world average production being about 760 Kwts. The average production of West Pakistan is 20 Kwts.

**Hasan Kabir**

# STATISTICAL SUPPLEMENT

## TABLE I—AREA UNDER MAJOR CROPS IN PAKISTAN

(In thousand acres)

| Crops | 1948-49 | 1949-50 | 1950-51 | 1951-52 | 1952-53 | 1953-54 | 1954-55 | 1955-56 | 1956-57 | 1957-58 | 1958-59 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rice | 21,499 | 21,833 | 22,400 | 22,482 | 23,020 | 24,532 | 23,704 | 21,904 | 22,445 | 22,962 | 22,494 |
| Wheat | 10,686 | 10,432 | 10,89 | 10,240 | 9,529 | 10,524 | 10,653 | 11,286 | 11,774 | 11,761 | 12,020 |
| Bajra | 2,331 | 2,369 | 2,407 | 2,019 | 2,213 | 2,585 | 2,192 | 2,199 | 2,297 | 1878 | 19,71 |
| Jowar | 1,185 | 1,365 | 1,255 | 1,091 | 1,317 | 1,511 | q,017 | 1,297 | 1,353 | 922 | 1,106 |
| Maize | 952 | 1,002 | 948 | 979 | 1,072 | 1,072 | 1,059 | 1,059 | 1,060 | 1086 | 1180 |
| Barley | 658 | 584 | 512 | 516 | 568 | 603 | 537 | 580 | 580 | 629 | 519 |
| Gram | 3,003 | 2,600 | 2,957 | 2,311 | 2,235 | 2,765 | 3,262 | 3,345 | 3,368 | 32,61 | 3222 |
| Total of foorgrains | 40,314 | 40,185 | 41,372 | 39,638 | 39,861 | 43,586 | 42,437 | 41,670 | 42,877 | 42,499 | 42,512 |
| Sugarcane | 708 | 770 | 696 | 704 | 873 | 983 | 1,016 | 967 | 1,017 | 12,34 | 12,95 |
| Rape and Mustard | 1,512 | 1,385 | 1,626 | 1,867 | 1,545 | 1,583 | 1,779 | 2,008 | 1,935 | 108 | 19,57 |
| Cotton | 2,653 | 2,799 | 3,072 | 3,375 | 3,479 | 2,928 | 3,193 | 3,537 | 3,560 | 3,563 | 33,06 |
| Jute | 1,877 | 1,561 | 1,711 | 1,779 | 1,907 | 965 | 1,243 | 1,634 | 1,230 | 1,563 | 15,28 |
| Tea | 73 | 74 | 75 | 82 | 73 | 75 | 74 | 77 | 75 | 76 | 76 |
| Tobacco | 164 | 169 | 179 | 174 | 173 | 193 | 245 | 205 | 205 | 195 | 199 |
| Total of Commercial | 6,987 | 6,758 | 7,359 | 7,991 | 8,050 | 6,727 | 7,550 | 8,428 | 8,022 | 8,439 | 8,361 |
| Grand Total | 47,301 | 46,934 | 49,731 | 47,629 | 47,911 | 50,313 | 49,987 | 50,098 | 50,899 | 50,938 | 50,873 |

## TABLE II—ESTIMATED PRODUCTION OF MAJOR CROPS

| Crops | 1948-49 | 1949-50 | 1950-51 | 1951-52 | 1952-53 | 1953-54 | 1954-55 | 1955-56 | 1956-57 | 1957-58 | 1958-59 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | (Thousand tons) | | | | | | |
| Rice | 8,408 | 8,171 | 8,195 | 7,756 | 8,151 | 9,152 | 8,409 | 7,209 | 9,052 | 8,487 | 7,890 |
| Wheat | 3,993 | 3,885 | 3,950 | 2,972 | 2,390 | 3,599 | 3,172 | 3,309 | 3,624 | 3,652 | 3,863 |
| Bajra | 394 | 371 | 385 | 266 | 267 | 262 | 347 | 348 | 366 | 281 | 303 |
| Jowar | 242 | 269 | 243 | 204 | 220 | 278 | 219 | 252 | 246 | 174 | 215 |
| Maize | 376 | 404 | 384 | 387 | 348 | 404 | 426 | 449 | 454 | 447 | 466 |
| Barley | 191 | 162 | 144 | 116 | 109 | 143 | 123 | 148 | 152 | 173 | 139 |
| Gram | 804 | 653 | 791 | 475 | 368 | 616 | 657 | 720 | 711 | 600 | 688 |
| Total of foodgrain | 14,408 | 13,915 | 14,092 | 12,167 | 11,853 | 14,654 | 13,353 | 12,435 | 14,605 | 13,814 | 13,564 |
| Raw Sugar | 1,043 | 1,081 | 883 | 879 | 1,089 | 1,279 | 1,245 | 1,204 | 1,226 | 14816 | 15,418 |
| Rape and Mustard | 26,267 | 229 | 284 | 305 | 226 | 263 | 322 | 321 | 326 | 332 | 299 |
| | | | | | Thousand bales | | | | | | |
| Cotton lint (a) | 989 | 1,267 | 1,515 | 1,650 | 1,900 | 1,444 | 1,596 | 1,850 | 1,800 | 1,666 | 1,547 |
| Jute (b) | 5,483 | 4,157 | 5,950 | 6,850 | 6,305 | 4,127 | 4,662 | 5,592 | 5,592 | 62 | 60 |
| | | | | | Million pounds | | | | | | |
| Tea | 34 | 39 | 38 | 53 | 52 | 52 | 54 | 53 | 54 | 42,5 | 538. |
| Tobacco | 142 | 149 | 162 | 179 | 167 | 194 | 184 | 211 | N.A. | 2.2 | 215 |

(a) Bales of 392 lbs. each. The figures are trade estimates. (b) Bales of 400 lbs. each.

# Book Reviews

## 1. THE PATTERN OF ASIA.

Edited by NORTON GINSBURG, Department of Geography, University of Chicago.

Jointly written by JOHN E. BRUSH, Department of Geography, Ratgers, the State University.

SHANNON MCCUNE, PROVOST, University of Massachuseetts.

ALLEN. K. PHILLBRICK, Department of Geography, Michigan State University.

JOHAN R. RANDAL, Department of Geography, Ohio State University.

HEROLD J. WINES, Department of Geography, Yale University.

Published in 1958, Prentice Hall, Inc. Englewood Cliffs, F.J., U.S.A.

The book comprises 907 pages of script 38 maps and 161 Figures. It is divided into six sections, mentioned below including 39 Chapters.

(1) General Asia.
(2) East Asia
(3) South East Asia
(4) South Asia
(5) South West Asia
(6) Soviet Union

There is a general background provided in the introductory chapters of each of these sections to prepare the reader for a detailed regional study. The entire book combines a geographico—economic study in the perspective of recent political changes on the map of Asia. Different authors, with specialised knowledge of their respective fields of study, have lent the book an authentic character. The monotony of expression and arrangement of topics usually present in books on regional studies is absent. Treatment of the various countries is such that, by laying stress on its salient aspects their individuality is brought out.

The section on general Asia clearly brings out the Asiatic Character of the continent, with all its diversities. In reviewing Asia's resources, the authors have rightly given it a place more befitting its area and po pulation.

The concept of "Asian Asia", non-European in culture and civilisation has matured in the term of "Asiatic Crescent" so frequently referred to in the book. It excludes, Soviet Asia, which inspite of the thousands of miles long common frontier with many countries of Asia, has remained different.

The authors have devoted some 245 pages on the section on East Asia. The treatment of China alone covers some 119 pages perhaps in proportion to the vast resources of its land and people. Agriculture and food supply problem is dealt with in great detail.

In the chapters on Japan prominent place is given to its industrial character, along with the problem of food supply for its acute land-man ratio.

In the section on South-East Asia, a mosaic of islands and seas, correlation of diverse land-use pattern with the distribution of population has been borne out.

In the treatment of the realm of South Asia, India has been the focus of attention. Its ethnic groups with their cultural heritage are presented in an interesting manner. Ancient India has been given due place in the treatment. And developments in the field of intensive agriculture, industry and urbanisation in modern India have been properly emphasised to give a clear cut idea of the grafting of the present on the past.

The section of Pakistan, though introduces the country well, is short of much information. A mere reference to the food and population problem is not enough. Sub-sections on the provinces of Pakistan are rather inadequate perhaps for want of space.

South-West Asia is introduced as a land of oil and political chaos. Socio-economic problems of the region, like poverty, nomadism and oil which have involved it deeply in the world politics have been given adequate treatment.

Soviet Asia is treated in the last two chapters. The country is dealt with as a whole in relation to Asiatic continent. Some comparisons and different values of the European and Asiatic sections of the Union present a glaring contrast specially in terms of people and their numbers. One feels quite satisfied as far as the discussion on Soviet Asia alone is concerned.

The book contains a number of detailed maps which need be studied at length. Unlike maps usually present in other books, these are quite complex and do not give a good account at a first glance. Maps on the front and back covers are also very informative suggesting correlation of physical environs and human response.

Figures cover a wide range of topics, from historic monuments to modern cities, intensively used land in China to vast stretches of yet vacant land of the ordos, and areas of shifting cultivation in Palawan island of Philippines to the terraced paddy fields of Java Most of these figures are of high illustrative value.

MARYAM K. ELAHI.

2. AN ECONOMIC GEOGRAPHY OF EAST PAKISTAN, BY NAFIS AHMED, , 325 pp. 56 maps and 59 tables, bibliography, index etc. (Oxford University Press, London, New York, Karachi), 1958.

Since the birth of Pakistan, this perhaps is the first book providing a detailed study of the economic conditions of the eastern wing of the country. It has been well illustrated with excellent sets of maps and 59 tables. Anybody who has done some research work on any of the Asian countries, will realize the colossal amount of work done in collecting the statistical data required for the above stated maps and tables in the book.

Structurally the book is a systematic study of East Pakistan. Each topic has been dealt with in a very relevent proportion. First 67 pages are about relief, climate and soils, 32 are devoted to describe the economic conditions of the past. This historical approach is valuable because it brings out a sequence of economic development. The description in the book shows three stages, ancient, Mughal and the 19th century stage. Ancient time is shown to be a prosperous one having a balanced economy——balanced between agricultural and industrial activities———During the Mughal period it improved further because of the flourishing inland as well as foreign trade. In the 19th century it started declining which continues even today. The loss of prosperity is shown to be due to the changed pattern of economy from a balanced one to an agrarian one. This change took place after the innovation of jute cultivation, which made the province a new-material exporter. In this context reference to the social and cultural factors responsible for the increase of population along with agrarian base of the economy seems rather neglected.

The largest proportion of the book is about the present economic conditions spread over 123 pages. Distribution of various resources primary as well as industrial along with their latest trends in development are discussed but one misses a chapter on the fisheries of East Pakistan badly Fishing is so important in E. Pakistan, both, as regards its occupational value as well as food supply. Except a general remark about the abundance of fish as food on page 77, fish seems to disappear altogether.

The chapter on communication is very enlightening. It seems that Pakistan government should spend more on the development of water transport rather than the development of land transport. In the end it may be said that the author seems to advocate the cause of East Pakistan for the restoration of a balanced economy.

The work is commendable.

KANIZ F. YOUSUF.

(2) **Shorter Contributions** of research and semi-research type which present a summary of work in progress and results achieved. General accounts of field trips are also included in this category. These contributions should not exceed 1,500 words in length.

(3) **Correspondence** in which contributors may communicate their views and comments on papers appearing in the journal. A space limit of 1000 words should be observed.

(4) **News and Notes** which contain brief accounts of new discoveries of resources, deveiopment projects and other news of geographical interest. They should not exceed 500 words in length.

3. The manuscripts should be typewritten, double spaced, typed on one side of the paper with wide margins. Tne diagrams and photographs should be clear. The tables should be consistent with the size of the Review. References should be listed at the end of the paper either in order of citation or alphabetically and indicated in the text by the corresponding number written in parenthesis.

4. The contributions are accepted with the understanding that they have not been published elsewhere.

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