Some Factors Affecting Tea Production in Pakistan

by

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and

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INTRODUCTION

The nature of the tea plant, *Camellia sinensis*, is such that certain natural factors heavily influence where it can be grown and how productive it will be. Among these factors, rainfall. temperature, and soil quality (particularly, drainage) seem to be the most important and have limited tea production essentially to South and Southeast Asia (although an increasing amount, 5 to 6 per cent of world production in recent years, is being grown in certain areas of Africa and Latin America) [4, p. 77; 3, p. 50]. The climate of East Pakistan is suitable for tea, and the hills of the Sylhet district in the northeast and the Chittagong district in the southeast have provided the required soil and drainage conditions to make Pakistan the seventh largest tea-producing country in the world. About 3 per cent of the world's output is grown in East Pakistan, and of this, over 90 per cent is grown in the Sylhet district alone.

The recent position of tea in Pakistan, at least in its broad outlines, is quite familiar even to the casual student of the Pakistan economy. Essentially static production, combined with rapidly increasing internal consumption, has resulted in a continual decline in exports during the past decade. These trends can be clearly seen in Figure 1. Exports of 34.13, 26.03, and 21.03 million pounds in 1951/52, 1954/55, and 1956/57, respectively, yielded earnings of Rs. 42.07 million, Rs. 55.78 million, and Rs. 51.43 million (about 3 per cent of total export earnings), in these three years [13]. During the past year (1963/64), tea exports have been nil. Whereas over 60 per cent of total production was exported in 1951/52, essentially all tea produced was consumed domestically in 1963/64. In light of the foreign-exchange shortage and the great need to expand exports, the Pakistan tea "story" is an unhappy one, indeed.

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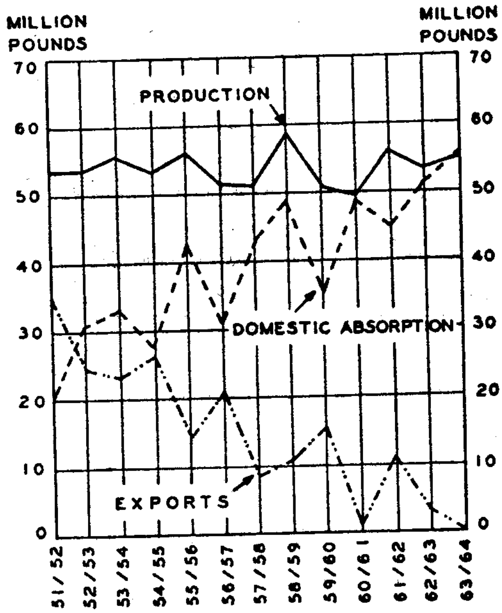

FIGURE 1. TEA: PRODUCTION, DOMESTIC ABSORPTION, EXPORTS

SOURCE: TABLE III

Perhaps, the most striking feature of this problem is the complete stagnancy of tea production during the past dozen years; there is some evidence, however, that this fact has not been widely known or fully appreciated. In the Pakistan five-year plans, for example, a significant upward trend emerges from the beginning benchmark figures, as shown in Table I, Row 1. The benchmark for the First Plan was 52.8 million pounds, which was the average for the four pre-plan years, 1951/52 to 1954/55 [29, p.132]. The second-plan benchmark was higher, 54.3 million pounds, and was the average of the five years 1954/55, 1955/56, 1956/57, 1958/59, and 1959/60 [29, p. 134]. Production in 1957/58, which was only 44.5 million pounds, was omitted, and production for 1954/55 of 54.0 million pounds was included in calculating the average for the benchmark, so that it was higher than the averages both for the first-plan (52.4 million pounds) and for the pre-plan period[1]. The third-plan benchmark is the estimated pro-

[1]The data used in this paragraph are those of the Planning Commission and they differ slightly from the data of the Central Statistical Office (CSO) and other agencies, which are given in Table II and in Appendix Table A-2.

duction for 1964/65, an estimate which is well above the average performance in recent years[2]. This upward trend of the plan benchmarks is paralleled by

TABLE I

TEA PRODUCTION IN THE PAKISTAN FIVE-YEAR PLANS

	First Plan 1955/56 to 1959/60	Second Plan 1960/61 to 1964/65	Third Plan 1965/66 to 1969/70
	(1)	(2)	(3)
	(..........	*million pounds*	..............)
1) Benchmark	52.8	54.3	62.0
2) Final-year target	60.7	63.8	79.0

Sources: Column (1): [29, p. 132].
Column (2): [29, p. 134].
Column (3): [28, p. 98].

the rising trend in the planned final-year targets, as can be seen in Table I, Row 2.

The record of past production does not lend support to these Planning Commission benchmark and target trends. Average tea production during the pre-plan, first-plan, and second-plan periods are given in Table II. Although the data of the Ministry of Food and Agriculture (MFA), Pakistan Tea Association (PTA), Central Statistical Office (CSO) and Central Board of Revenue (CBR) are all different, they uniformly indicate that the production figures have been static during the past twelve to thirteen years[3].

There are many facets to this problem involving, among other things, government policies, the pattern of estate ownership and market structure, as well as domestic and international demand conditions. Although the present study relates to this broader, complex problem, it is focussed essentially on two aspects: *first*, the major characteristics of the rise in consumption (Section II);

[2] The figure of 62 million pounds is the benchmark given in Planning Commission's *Outline of the Third Five-Year Plan* [28, p. 98], and is the same as recent estimates of a bumper crop for 1963 or 1963/64 [20]. On another page of the *Outline* [28, p. 241], both 62 and 64 million pounds (the second-plan target) are given as the benchmark for the Third Plan. This latter figure must be an error.

[3] We are not implying that the Planning Commission has failed to take note of the data on actual production, since they have reported these in several documents. (*See*, for example, [28, p. 132] and [27, p. 114] for figures on the first- and second-plan periods.) Rather, the benchmark and target-year figures indicate that the lack of trend implied in the data reported may not have been fully appreciated.

and *second,* the factors which seem to have been most important for tea production, namely, acreage, rainfall, and temperature (Section III). The analysis in Section III places heavy emphasis on factors causing short-run fluctuations in tea production and sheds some light on the possibility of reaching the targets set out in the Second and Third Five Year Plans. These targets are carefully assessed in the concluding Section IV.

TABLE II

AVERAGE TEA PRODUCTION IN PAKISTAN

Agency	Pre-Plan 1951/52 to 1954/55 (four years)	First Plan 1955/56 to 1959/60 (five years)	Second Plan 1960/61 to 1963/64 (four years)
	(1)	(2)	(3)
	(...........*million pounds*..............)		
1. MFA	51.11	52.47	51.95
2. PTA	53.12	52.44	52.22
3. CSO	54.22	53.67	53.89
4. CBR	55.23	53.09	53.19

Source: Appendix Table A-2.

Note: In Column (1), CBR data are available only for two years, 1953/54 and 1954/55. In Column (3), PTA data only go through 1961/62 (two years); and CBR data are available only through 1962/63 (three years).

In the process of preparing this paper, many data problems were encountered. In some cases, critical data were not available, and in many other cases there were too many statistics: conflicting figures were given in several different sources (as in the case of Table II above). Although, we have followed the usual procedure of relegating these statistical problems to an appendix, they are so important that the reader is urged to study Appendix A, in particular, with great care. Our analysis and conclusions could well be changed when better and more consistent data become available.

II: TEA ABSORPTION IN PAKISTAN

Because of the lack of complete and reliable data on tea stocks, actual consumption cannot be correctly estimated. Therefore, we have analysed "tea absorption", defined as production *plus* imports *minus* exports. Although in any particular year consumption and absorption will diverge by the amount of inventory changes, the trend in absorption over several years will closely approximate the trend in consumption.

For the period, 1951/52 through 1963/64, the data on production, domestic absorption, and exports are shown in Figure 1 and Table III. As can be seen, there have been substantial year-to-year fluctuations in all the three variables. While there is no discernible trend in production, steadily increasing absorption has been at the expense of declining exports. Tea absorption doubled during this period, growing on the average at an annual rate of 6.3 per cent; the average annual increase was 2.29 million pounds[4]. Part of this increase was due to population

TABLE III

ABSORPTION OF TEA IN PAKISTAN

Year (July-June) (1)	Production (2)	Imports (3)	Exports (4)	Total domestic absorption (5)	Absorption per capita (6)
	(............*million pounds*............			)	(*pounds*)
1951/52	53.76	0.67	34.13	20.30	0.25
1952/53	53.75	0.99	24.22	30.52	0.36
1953/54	55.92	0.44	23.33	33.03	0.38
1954/55	53.43	0.37	26.03	27.77	0.31
1955/56	56.03	0.44	14.08	42.39	0.47
1956/57	51.53	0.20	21.03	30.70	0.33
1957/58	51.20	0.24	8.36	43.08	0.46
1958/59	58.84	0.14	10.58	48.40	0.50
1959/60	50.76	0.24	15.76	35.24	0.36
1960/61	49.89	0.24	0.49	49.64	0.49
1961/62	56.04	0.26	11.36	44.94	0.43
1962/63	53.65	0.74	3.12	51.27	0.48
1963/64	55.00	0.52	0.00	55.52	0.50

Sources: Column (2): 1951/52 to 1962/63, [12]; 1963/64, [19].
Column (3): 1951/52 to 1956/57, [6]; 1957/58 to 1959/60, [11]; and 1960/61 to 1963/64, [14].
Column (4): 1951/52 to 1962/63, [12, 13]; 1963/64, [14].
Column (5): Column (2) *plus* Column (3) *minus* Column (4).
Column (6): Column (5) divided by the population, as estimated in Appendix Table B-9.

[4] A least-squares regression equation was fitted to the total absorption data in Table III. (The 1963/64 figure is excluded as it is based on preliminary estimates.)

$$A_t = 23.232 + \underset{(0.476)}{2.288}\, y_t :$$

$n = 12$; $r^2 = 0.70$

$t = 4.81$ (significant at the 99-per-cent confidence level); where A is annual absorption; y represents the years 1951/52 to 1962/63; n is the number of observations; r^2 is the coefficient of determination; the number (0.476) in parentheses under the coefficient of the independent variable (the *b* coefficient) is the standard deviation of this coefficient; t is the b coefficient divided by its standard deviation. The t-test reveals the statistical significance of the regression equation, which in this instance is at the 99-per-cent confidence level. These definitions of n, r^2, and t will be used throughout this article. (This *t* used for the test of statistical significance should not be confused with the subscript used for denoting the time period, as A_t above.) The trend absorption for 1951/52 was 25.52 million pounds and for 1962/63, 50.69 million pounds. On the basis of these trend values, the compound annual rate of absorption growth was 6.4 per cent. Using three-year averages for 1951/52 to 1953/54 and 1960/61 to 1962/63 as the beginning and ending values, the annual growth rate was essentially the same, 6.3 per cent. (This is the figure given in the text.) Including 1963/64 in the final three-year average lowers the rate slightly to 6.1 per cent.

growth of over 2 per cent per year. After accounting for this, however, per-capita absorption rose at an annual rate of about 4 per cent, from less than one-third of a pound in the early 1950's to almost one-half pound a decade later (as shown in Table III, Column (6)). The average annual per-capita absorption over the period was 0.41 pounds. Although the per-capita increase may be partly explained by rising per-capita income, particularly since 1958, it is probably due largely to growth of the urban areas, where tea is mainly consumed. Between 1950 and 1960, urban population increased over 56 per cent, rising from about one-tenth to about one-eighth of the total population [28, p. 10].

The breakdown of tea absorption by the two provinces is given in Table IV (East Pakistan) and Table V (West Pakistan). All commercial tea production is in the East Wing, but most has been exported, either abroad or to West Pakistan, so that annual per-capita absorption in the East Wing averaged 0.14 pounds throughout the period, just over one-third of the national average. Although East Wing per-capita absorption was quite low, it doubled from an average of 0.11 pounds per annum during the three-year period 1951/52 to 1953/54 to an average of 0.22 pounds for the three years 1960/61 to 1962/63 (reflecting a growth rate of about 8 per cent per year). Total absorption increased on the average by about 10.9 per cent, or about 641,000 pounds, per year[5].

In West Pakistan, per-capita absorption averaged 0.71 pounds per year ; almost twice the national average. The total-absorption data (Table V, Column (5)), revealed an annual rate of growth of 5.1 per cent or about 1.648 million

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[5] The following least-squares equation was fitted to the East Pakistan total absorption data:

$$A_t = 3.312 + \underset{(0.469)}{0.641}\, y_t;$$

$$n = 12;\ r^2 = 0.16;$$

$$t = 1.37 \text{ (not significant)};$$

where A is annual absorption and y represents the years 1951/52 to 1962/63. The t-test reveals that the correlation is significant at only the 80-per-cent confidence level, and all levels below 90 per cent a re labelled "not significant" in this article. There appears to be no statistically significant trend using this method because the annual fluctuations in tea absorption are very large with highs of 7.45 and 8.59 million pounds in the early years of 1953/54 and 1955/56 respectively, and lows of —4.72 and 6.46 million pounds in the later years of 1959/60 and 1961/62. However, we feel that these fluctuations conceal a meaningful trend, due to the fact that tea stocks (and, therefore, fluctuations in stocks) are mainly concentrated in East Pakistan. Since consumption there is low, stock changes have a disproportionate effect on absorption, even causing it to be negative (—4.72) in 1959/60, when the decline in stocks must have exceeded consumption. The compound annual growth rate of 10.9 per cent was calculated by using the three-year averages for 1951/52 to 1953/54 and 1960/61 to 1962/63 as terminal values.

TABLE IV

ABSORPTION OF TEA IN EAST PAKISTAN

Year (July-June)	Production	Imports from abroad	Exports to		Absorption	
			Abroad	West Pakistan	Total	Per-capita
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	(...million pounds				...)	(pounds)
1951/52	53.76	0.09	33.01	17.14	3.70	0.08
1952/53	53.75	0.16	23.53	26.63	3.75	0.08
1953/54	55.92	0.10	22.65	25.92	7.45	0.16
1954/55	53.43	0.08	24.36	23.16	5.99	0.12
1955/56	56.03	0.12	12.98	34.58	8.59	0.17
1956/57	51.53	0.06	19.55	28.38	3.66	0.07
1957/58	51.20	0.09	6.20	33.22	11.87	0.23
1958/59	58.84	0.09	8.87	38.12	11.94	0.23
1959/60	50.76	0.08	15.44	40.12	—4.72	—0.09
1960/61	49.89	0.07	0.49	35.27	14.20	0.26
1961/62	56.04	0.09	11.36	38.31	6.46	0.11
1962/63	53.65	0.56	3.11	34.03	17.07	0.29

Source notes: Columns (2), (3), and (4): same sources as Columns (2) (3), and (4) of Table III.

Column (5): 1951/52 [6]; 1952/53 to 1955/56, and 1958/59 to 1960/61, [13]; 1956/57, 1957/58, 1961/62, 1962/63, [12]. The CSO *Statistical Yearbooks* [13] for both 1962 and 1958 give 18.58 and 43.22 million pounds for 1956/57 and 1957/58. This diverges from the CSO *Statistical Bulletin* [12] figures which are given here (because they are also essentially the same as those given by The Pakistan Tea Association (PTA) [35].

Column (6): Column (2) *plus* Column (3) *minus* Column (4) *minus* Column (5).

Column (7): Column (6) divided by population as given in Appendix Table B-9.

TABLE V

ABSORPTION OF TEA IN WEST PAKISTAN

Year (July-June)	Imports from abroad	Exports abroad	Imports from East Pakistan	Absorption	
				Total	Per-capita
(1)	(2)	(3)	(4)	(5)	(6)
	(................*million pounds*.................			)	(*pounds*)
1951/52	0.58	1.12	17.14	16.60	0.45
1952/53	0.83	0.69	26.63	26.77	0.71
1953/54	0.34	0.68	25.92	25.58	0.66
1954/55	0.29	1.66	23.16	21.79	0.55
1955/56	0.32	1.11	34.58	33.79	0.83
1956/57	0.14	1.48	28.38	27.04	0.65
1957/58	0.16	2.16	33.22	31.22	0.73
1958/59	0.05	1.71	38.12	36.46	0.83
1959/60	0.15	0.32	40.12	39.95	0.89
1960/61	0.16	0.00	35.27	35.43	0.77
1961/62	0.16	0.00	38·31	38.47	0.81
1962/63	0.19	0.00	34.03	34.22	0.70

Sources: Columns (2), (3), and (4): same as sources for Table IV, Columns (3), (4), and (5), respectively.

Column (5): Column (2) *minus* Column (3) *plus* Column (4).

Column (6): Column (5) divided by population as given in Appendix Table B-9.

pounds[6]. Per-capita absorption rose from an average of 0.61 pounds for the three years 1951/52 to 1953/54, to an average of 0.76 pounds for 1960/61 to 1962/63, an increase of about one-fourth (or about 2.5 per cent per year).

Thus, the marked rise in tea absorption is common to both the provinces. This rise is very rapid relative to tea production and has forced a reduction in much needed exports. Further, it is rapid relative to the increase in per-capita income (which, on the average, rose 0.1 per cent per year during the decade prior to 1959/60 and has risen 2.1 per cent annually since 1959/60 [28, p. 11], so that it may reflect " consumption liberalization " at the expense of saving[7]. Thus, on grounds both of export potential and saving potential, the increasing domestic absorption of tea is economically undesirable.

As would be expected with a static supply and increasing demand, retail prices have risen steadily, approximately doubling during the past decade, as shown in Table VI[8]. In response to this price increase, the Government has restricted (and in the past year, banned) tea exports, hoping thereby to ease the domestic-market situation and hold prices down. Consequently, in this instance, the Government's goal of deterring price increases is in direct conflict with its export and savings goals.

Unless the growth of domestic tea absorption is curtailed below the current rate, Pakistan will be forced to import on a large (and increasing) scale. Further, if tea is to resume its position as a significant contributor to foreign-exchange earnings, then substantial restraint on consumption must be exercised. Although, there is a potential for expanding production, as discussed in the next section, it is practically impossible for the production growth-rate to change from zero to more than 6 per cent per year, particularly in the near future.

Even though the per-capita absorption of tea has risen by about 4 per cent per year during the past twelve years, annual absorption per head is still only one-half pound. As can be seen in Table VII, Pakistan's per-capita absorption for the most recent years is less than one-tenth the amount consumed in the advanced-tea drinking countries, and—even more important—it is less than 1955-57 figure for the major tea producing countries. Comparison with these

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[6] The least-squares regression was as follows:

$$A_t = 19.921 + \underset{(0.342)}{1.648}\, y_t\ ;$$

$n = 12$; $r^2 = 0.70$;

$t = 4.81$ (significant at the 99-per-cent confidence level);

where A is annual tea absorption in West Pakistan; and y represents the years 1951/52 to 1962/63. The annual compound rate of growth was calculated in the same manner as for the East Wing and all Pakistan, on the basis of three-year averages.

[7] *See*, Khan [8] and Power [38].

[8] The general price level has also risen during this period, but not as much. The price indices given by the CSO [12] indicate that the increase in the general price level has been about 30 per cent, compared to the tea price increase of 100 per cent.

other countries indicates that Pakistan's consumption is quite low, and a continuously increasing demand for tea can be expected. Consequently, although some reduction in the high rate of increase of domestic absorption is essential, particularly in the short-run, the greatest emphasis must be placed on increasing production.

TABLE VI

AVERAGE RETAIL PRICE OF TEA IN PAKISTAN

Year (July-June)	Average retail price at Karachi	Average retail price in East Pakistan	Average price in Pakistan
(1)	(2)	(3)	(4)
	(.....................	*rupees per pound*	..............)
1952/53	2.20	2.48	2.34
1953/54	2.40	2.63	2.52
1954/55	3.24	3.11	3.18
1955/56	3.54	3.65	3.60
1956/57	3.25	3.60	3.42
1957/58	3.44	3.41	3.42
1958/59	3.56	3.52	3.54
1959/60	4.16	4.55	4.36
1960/61	4.05	4.15	4.10
1961/62	4.03	3.88	3.96
1962/63	4.86	4.87	4.86

Source: Columns (2) and(3): figures derived from monthly data for Lipton and Brooke Bond Tea [12]: Column (3) is for Dacca, Chittagong, and Narayanganj.
Column (4): The simple average of Columns (2) and (3).

TABLE VII

TEA CONSUMPTION PER CAPITA IN SELECTED COUNTRIES: 1955-57

I) Tea-drinking Advanced Countries	*(pounds)*
United Kingdom	9.74
Ireland	8.05
New Zealand	6.81
Australia	5.93
II) Tea-producing Countries	
Ceylon	2.01
Japan	1.50
Malayan Federation	1.26
Indonesia	0.71
India	0.57
Pakistan (1961-63)	0.47

Source notes: For all countries except Pakistan, *see* [4, p. 11]. The figure for Pakistan is the average for 1961/62 through 1963/64; (*see*, Table III). The per-capita tea consumption in the United States, a "non-tea-drinking" advanced country, was 0.64 during 1955-57 [4, p. 11].

III: TEA PRODUCTION IN PAKISTAN

The most important fact about tea production in Pakistan has been stressed above, namely that, although there have been substantial year-to-year fluctuations, there has been no upward trend (*see*, Figure 1 and Table II)[9]. Some perspective on this problem can be gained by comparing Pakistan with the other eleven major tea-producing countries, the data for which are given in Table VIII (as presented by the Commonwealth Economic Committee [3, pp. 49-50]). Table VIII-A reveals that, in 1959/60, Pakistan ranked seventh in production, eighth in acreage, and sixth in yield per acre. More relevant, however, are the changes between the two-year averages for 1954/55 and 1959/60 (Table VIII-B). Ten of the twelve countries registered increases in production ranging from 12 per cent (India) to 300 per cent (Argentina). In Pakistan and Indonesia production fell; in the case of Indonesia, this was due to an 11-per-cent contraction in acreage, but in Pakistan acreage increased 4 per cent. In nine of eleven countries (statistics on Mainland China are not complete), yields per acre (production/acreage) rose from 1 per cent (Kenya) to 162 per cent (Argentina). Only in Pakistan and Japan did yields fall, and in the case of Japan this was probably due to the rapid expansion of acreage (31 per cent), with much land under low-yielding or nonyielding young plants. (The low increase in Kenya's yields—only 1 per cent—must also be due largely to a 58-per-cent acreage expansion.) Pakistan is unique in that its production failed to increase (in this period, it actually fell) in spite of some increase in acreage.

This conclusion is supported by Pakistani data over a longer period, although certain statistical problems must be noted. In 1960, the official concept of tea acreage changed from "Registered Acreage" to "Area under Tea," so the pre-1960 figures and those for 1960 and after are not comparable, "Area under Tea" being 2 to 3 per cent smaller than the former concept[10]. Further, area estimates for the early years following independence in 1947 are not reliable as "it was not until 1951 that tea estates were called upon to submit details of their acreage under tea, *etc.*, to Government" [37].

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[9] This conclusion is supported by least-squares equations which were fitted to the annual production data of the CSO, PTA, and MFA. In the case of CSO and PTA, there was a slightly negative trend; and with the MFA data, the trend was slightly positive. In all cases, however, the t-test revealed that the trends were not significantly different from zero.

[10] For a discussion of this point, see the section on acreage statistics in Appendix A.

TABLE VIII-A

TEA PRODUCTION, ACREAGE, AND YIELDS IN THE MAJOR TEA-PRODUCING COUNTRIES[a]

Country	1954-1955 (two-year average)			1959-1960 (two-year average)					
	Production (million pounds)	Acreage (Thousand acres)	Yield (pounds per acre)	Production (million pounds)	Production Rank	Acreage (thousand acres)	Acreage Rank	Yield (pounds per acre)	Yield Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
India	665	792	840	744	1	816	1	910	2
Ceylon	374	572	650	445	2	581	3	770	4
China	221	—	—	344	3	800[c]	2	430	10
Japan	156	91	1,710	178	4	119	7	1,500	1
Indonesia	100	200	500	98	5	178	4	550	8
USSR	59[b]	174[b]	340[b]	79	6	157	5	500	9
Pakistan	*54*	*75*	*720*	*51*	*7*	*78*	*8*	*650*	*6*
Formosa	31	113	270	40	8	120	6	330	11
Kenya	18	24	750	29	9	38	10	760	5
Nyasaland	18	26	690	25	10	30	12	830	3
Mozambique	18	29	450	22	11	37	11	590	7
Argentina	4	49	80	16	12	76	9	210	12

Source: [3, pp.49-50].

Notes: a) These twelve countries account for over 95 per cent of world tea production.
b) Average of 1955 and 1956.
c) Estimate for 1958 [3, p. 50]. If China's acreage-expansion plans were fulfilled, they must have ranked ahead of India by 1960.
Dash (—) means not available.

TABLE VIII-B

PERCENTAGE CHANGES IN TEA PRODUCTION, ACREAGE, AND YIELD BETWEEN 1954/55 AND 1959/60

Country	Changes in production		Changes in acreage		Changes in yield	
	Per cent	Rank	Per cent	Rank	Per cent	Rank
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Argentina	300	1	55	2	162	1
Mozambique	69	2	28	4	31	3
Kenya	61	3	58	1	1	9
China	56	4	—	—	—	—
Nayasaland	39	5	15	5	20	5
USSR	34	6	—10	10	47	2
Formosa	29	7	6	6	22	4
Ceylon	19	8	2	9	18	6
Japan	14	9	31	3	—12	11
India	12	10	3	8	8	8
Indonesia	—2	11	—11	11	10	7
Pakistan	*—6*	*12*	*4*	*7*	*—10*	*10*

Dash (—) means not available. *Source:* Table VIII-A.

However, from 1952 to 1959, there was an upward trend, with, approximately, a 4,000-acre (5 to 6 per cent) increase over the period as a whole[11]. Since 1960, there has been a more rapid area expansion under The Tea (Amendment) Ordinance, 1960 [15, 1960][12]. According to the Pakistan Tea Board (PTB), the "Area under Tea" has risen from 78,160 acres in 1960 to 83,700 acres in 1963 (*see*, Appendix Table A-5). This latter figure is comparable to over 85,000 "Registered Acres," so the total expansion between 1952 and 1963 was approximately 12,000 acres. This 16-per-cent increase in area resulted in no additional production during this period[13].

Although there has been no trend, tea production has been characterized by substantial short-run fluctuations from month to month and from year to year. An analysis of these fluctuations, the subject of the next subsection, yields some insight into this broader tea-productivity problem.

Short-run Fluctuations in Tea Production

Annual variations in tea production have often exceeded 10 per cent, and changes in excess of 25 per cent have been reported for two of the past five years (*see*, Appendix Table A-2, MFA). For many crops, such variations are due to changes in acreage, but this is not the case in tea. Year-to-year acreage-shifts have been modest, ranging from 0 to 3 per cent, and they have borne no relationship to changes in output. Any expansion of acreage would not substantially affect production for about five years; and any contraction, since it would involve area under the oldest plants, would similarly have only the slightest

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11 We fitted least-squares equations to the data of *i*) the Pakistan Tea Board (PTB) [25] and *ii*) the East Pakistan Directorate of Agriculture [30]:

(1) $L_t = 71.81 + \underset{(0.12)}{0.65}\, y_t$;

$n = 8$; $r^2 = 0.83$;

$t = 5.37$ (significant at 99-per-cent confidence level).

(2) $L_t = 73.41 + \underset{(0.18)}{0.49}\, y_t$;

$n = 8$; $r^2 = 0.55$;

$t = 2.71$ (significant at the 95-per-cent confidence level).

L is the land area under tea ("Registered Acreage"); and y represents the years 1952—1959. In the case of the PTB (1), the trend values for 1952 and 1959 acreage were 72,460 and 76,980 acres, respectively, indicating a 4,520-acre or 6-per-cent increase over the period. From equation (2), the trend values were 73,900 and 77,350, reflecting a 3,450-acre or a 5-per-cent increment between the two years.

12 The basic ordinance is The Tea Ordinance, 1959 [15, 1959]. *See also*, the Tea Amendment Ordinance of 1962 [15, 1962].

13 Of course, this is due partly to the same factor mentioned above in the case of Japan. The new areas planted since 1959 have not yet made any significant contribution to output because it takes from four to six years for the tea plant to mature [4, p. 5]. However, they should have some effect on production during the Third Five Year Plan. (This point will be discussed below.)

Stated in terms of yields, productivity per acre fell from about 730 pounds in 1952 to 630 pounds in 1963.

impact on output. Because of this, and because of statistical problems discussed in Appendix A, we have excluded acreage from our analysis of short-run changes in production[14].

Similarly, variations in tea prices have also been excluded, as they do not seem to play a major role in output fluctuations. One might expect high prices now (with lower prices anticipated) to elicit greater plucking and production this month, at the expense of some future production (or *vice versa*). This is not the case, however, because the tea plant must be plucked regularly to obtain leaves of saleable quality:

> The bushes cannot be left unplucked as is the case with coffee or cocoa. Plucking at regular intervals is indispensible in order to obtain the growth of the young shoots and leaves used for tea manufacture [4, p. 5].

During the hot, humid, monsoon season, the plants grow so rapidly that picking is required every five to seven days, whereas during dryer, cooler weather, the cycle is every ten to twelve days. Thus, variations exist in the timing and intensity of plucking, but they are due to changes in natural, and not market, conditions[15].

Monthly tea production in East Pakistan is characterized by pronounced seasonality, with output usually below 500,000 pounds during the three months, January to March, increasing markedly from April to August and September, when it generally exceeds eight million pounds. This pattern is caused by seasonal changes in rainfall and temperature, and it differs substantially from Kenya and Java where these variables remain more steady throughout the year [4, p. 45; 5,p. 37]. Table IX shows the percentage distribution of rainfall and production for Sylhet, Kenya, and Java, and the differences are quite obvious. For the latter two countries, from 7 to 10 per cent of the crop is produced every month, whereas in Sylhet the range is from less than 1 per cent (during January and February), to over 15 per cent (during September). Deviations from the average monthly production, rainfall, and temperature in Sylhet are

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[14] Since all yield figures are derived by dividing production by acreage [37, p. 2; 25, p. 2], we have concentrated directly on production statistics and have not utilized yield estimates in the following analysis.

[15] To some degree, more tea of coarser quality can be plucked instead of less tea of finer quality [4, p. 52]. Consequently, diverse movements in the prices of the two qualities might have an effect on the amount picked in any one month or throughout the year. For example, if finer-quality prices were rising relative to those of coarse-quality tea, the profit incentive would lead to *lower* total production of tea. This aspect of the problem has not been included in the present study, however.

TABLE IX

RAINFALL AND TEA CROP DISTRIBUTION

Months	East Pakistan		Kericho, Kenya		Soekaboemi, Java	
	Rainfall	Crop	Rainfall	Crop	Rainfall	Crop
	(............................ *percentages*				............................)	
January	0.53	0.7	4.22	9	18.30	9
February	0.91	0.2	6.98	8	8.30	8
March	3.22	1.2	8.30	9	11.19	8
April	5.90	4.1	12.78	9	11.93	8
May	17.21	7.0	15.42	7	7.70	9
June	21.16	9.9	10.94	7	4.81	7
July	16.33	13.8	7.25	8	2.89	7
August	13.56	14.9	9.35	8	2.81	7
September	13.83	15.4	8.43	8	2.96	9
October	5.91	15.0	7.51	9	6.74	10
November	1.33	11.6	5.93	9	10.22	9
December	0.12	6.2	2.90	9	12.15	9
Total	100.0	100.0	100.0	100.0	100.0	100.0

Sources: Pakistan rainfall is based on Table B-2 and crop distribution is based on Table B-1 (CSO). Kericho, Kenya and Soekaboemi, Java crop distribution and rainfall [5, p. 29 and p. 37].

shown in Figure 2 and the similarity in pattern is quite clear. There is low rainfall, low temperature, and low production in the winter months, with all the three rising during the summer season. From December through February, the tea plant is relatively dormant as the minimum temperatures are from 40° to 60° Fahrenheit (and the average of the minimum and maximum temperatures is below 70°)[16]. From March through October, however, temperatures are sufficiently high for rapid tea-plant growth, so that the quantity produced depends heavily on rainfall during this period.

16 As shown in Appendix B, Table B-7, the mean minimum temperature for these three months (from 1948—1960) was, respectively, 50.3°, 47.1° and 51.3° Fahrenheit.

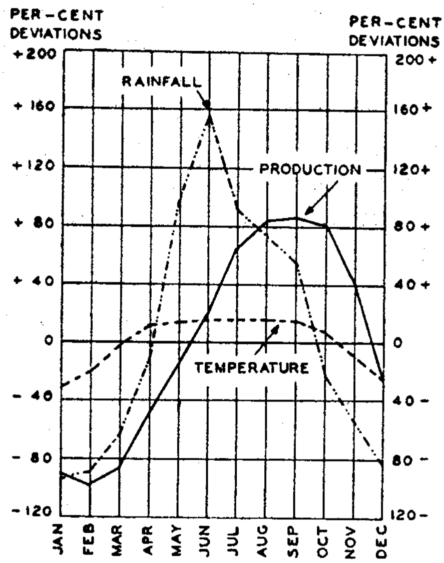

FIGURE 2. AVERAGE MONTHLY PRODUCTION, RAINFALL, AND MEAN TEMPERATURE, 1952-60 (PER-CENT DEVIATIONS FROM THE 108-MONTH MEANS)

Sources: Production: Based on Table B-1 (C.S.O.)
Rainfall: Based on Table B-2.
Temperature: Based on Tables B-7 and B-8 (converted to centigrade).

The Relationship Between Production and Rainfall

Because of the importance of rainfall, we initially tested a number of hypothetical relationships treating rainfall as the only explicit variable explaining changes in production. Perhaps, the most widely held hypothesis is that high annual production is due to a "good rainfall year." However, a regression equation fitted to the data for the fourteen-year period, 1948-61, revealed no significant correlation between annual production in East Pakistan and the total rainfall in the same year [40, p. 3][17]. We also tested the same relationship with data on annual production and annual rainfall for seven circles in the Sylhet district for the period 1959-62, and again the correlation was not good [40,

[17] Regression results which are statistically not significant (*i.e.*, those that are significant at less than the 90-per-cent confidence level) will not be reported here. Rather a reference will be made to the authors' earlier study where the details are given ([40, p. 3], in this instance). The production data are given in Appendix B, Table B-1. The rainfall data are given in Table B-2 and pertain to the Sylhet district where about 93-per-cent of the Pakistan tea crop is grown. (*See*, Appendix A for a critical analysis of both the production and rainfall statistics.)

p. 3][18]. This result is not really surprising, as it is similar to findings obtained in studies of other crops [39]; and it suggests that distribution of rainfall over the year is more important than the annual total amount.

The tea year can be divided into three seasons: *a*) the cool-dry period from October to March; *b*) the hot-dry period during March-April (and possibly May); and *c*) the hot-humid period from May to October during which most of the tea is produced. Since rain is usually ample during this third period, it is thought that changes in the amount of rainfall during the relatively dry periods may explain changes in production the following season. For example, according to the Secretary of the PTA:

> What is required is not heavy downpours of 6" per hour, but steady rain over prolonged periods, and more particularly at certain times of the year, *e.g.*, rainfall in October/November to help the bushes through the cold dry weather period, then further rain in March/April to assist the bushes to weather the dry windy periods prior to the monsoon [37].

To test this hypothesis, we fitted two separate regression equations as follows. *First,* we related rainfall during the October to March (cool-dry) period to production in the following January through October [40, p. 4]. *Second,* we tested the relationship between rainfall during the March to May (hot-dry) period and production during the following May through November [40, p. 4][19]. In neither case did the test yield significant results which raises serious doubts about any simple relationship between rainfall during the dry periods and production in the following season[20].

In Figure 2 above, there can be seen a pronounced similarity between the month-to-month changes in rainfall and production with a oneto three-month lag. Although, many alternative formulations of the relationship between the two variables on a monthly basis are possible, we tested only two and both revealed quite good correlations. *First,* for the 108-month period from 1952-60, we tested the relationship between production in each month and the amount of rainfall in the previous month, and we found it highly significant[21]. The

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[18] A circle is an administrative unit in East Pakistan.

[19] We actually fitted two regressions for the May-November production, using first the PTA production data from 1949 to 1961, and then that of the CSO, from 1952 to 1961.

[20] The results of additional tests of this hypothesis are reported below.

[21] $P_t = 2{\cdot}176 + \underset{(0.018)}{0.206}\, R_{t-1}$;

$n = 107;\ r^2 = 0.55$;

$t = 11.32$ (significant at the 99-per-cent confidence level);

$E = 0.51;\ \bar{P} = 4.48;\ \bar{R} = 11.21$;

where P is monthly tea production (million pounds), 1952—60; R is monthly rainfall (inches) for the same period; and E is the output elasticity with respect to rainfall at the average values of the variables. $\bar{P}$ is the average P; $\bar{R}$ is the average R. (Since the relationships calculated in this study are all linear, the elasticity differs for every combination of the variables. The elasticity coefficients given always relate to the average values of the variables.) Production data are from Table B-1 (CSO); rainfall data are from Table B-2.

coefficient of determination (r^2) was 0.55: 55 per cent of the variations in production are explained by changes in the previous month's rainfall. The rainfall coefficient was 0.206: a one-inch change in monthly rainfall was associated with a 206,000-pound change in production one month later. The elasticity coefficient was 0.51 at the average levels of monthly rainfall and production, so a 10-per-cent change in rainfall was followed by a 5.1-per-cent change in production one month later. *Second,* for the same period, we correlated the three-month moving-average of production with the three-month moving-average of rainfall, with a one-month lag[22]. The r^2 was 0.68 (and the correlation was also significant at the 99-per-cent confidence level); changes in the three-months rainfall explain over two-thirds of the variations in the three-month production (lagged one month).

Tea Production, Rainfall, and Temperature

As noted earlier (in connection with Figure 2), the temperature in Sylhet district follows a seasonal pattern comparable to that of production. The low minimum temperatures during the winter cause the tea plant to become relatively dormant, whereas the summer brings a warmth which facilitates rapid plant growth. Consequently, one possible reason why the correlation between production and rainfall is not higher is that the impact of temperature has been ignored.

One method previously used by some analysts of tea to test the effect on production of both rainfall and temperature is the "Lang's Factor," the ratio of precipitation (in millimeters) to temperature (centigrade)[23]. In a study of tea gardens in the Surma Valley, Sylhet district, Karim and Khan state:

> The data on the Lang's factor of the different Estates...show a good correlation with the yield of the respective Estates... . It is quite apparent from the data... that the yield varies inversely with the Lang's factor, *i.e.*, the yield falls with the rise of Lang's factor...[7, p. 731].

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22 $$P_t = 1.523 + \underset{(0.017)}{0.258}\, R_{t-1};$$
$$n = 106; \; r^2 = 0.68;$$
t = 14.99 (significant at the 99-per-cent confidence level);
$$E = 0.66; \; \bar{P} = 4.49; \; \bar{R} = 11.42;$$

where P is a three-month moving-average of tea production (million pounds), 1952-60; and R is a three-month moving-average of rainfall (inches) for the same period. Production data are from Table B-1 (CSO); and rainfall data are from Table B-2.

23 The Lang's factor is tested by Karim and Khan [7], who make reference to the original study by Lang [9].

This conclusion was based on data gathered from eleven estates over a five-year period. Those estates with the highest average yields over the five years generally had the lowest rainfall/temperature ratios[24].

The logic underlying the inverse relationship between the Lang's factor and tea production seems to be based on the direct correlation between production and temperature. Those estates located in areas where the winters are longer and cooler naturally tend to have lower yields. Given rainfall, a lower temperature in the denominator raises the Lang's factor, so the higher Lang's factor is associated with lower production.

We tested the relationship between monthly production and the rainfall-temperature ratio in the preceding month for the period 1952-60[25]. The results were quite surprising in comparison to the Surma Valley cross-sectional study: the correlation was positive; that is, monthly production varied directly with the previous month's rainfall-temperature ratio. The explanation for this positive relationship is that changes in rainfall from month to month, with which changes in production are positively correlated, were so great that they completely dominated the rainfall-temperature ratio; whereas in the cross-sectional study, the temperature differences among the eleven estates must have been the dominant factor[26].

This difference points up a profound theoretical weakness in the Lang's factor, since the impact of variations in the factor depends on whether the change

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24 Actually, the evidence given by Karim and Khan is inconclusive, as the data given, contrary to their belief, do not "show a good correlation." Although the r^2 is 0.70, there are only eleven observations and the t-test reveals that the correlation is significant at only the 90-per-cent confidence level :

$$Y = 32.823 - \underset{(0.127)}{0.250}\,F;$$

$$r = 11;\ r^2 = 0.70;$$

$$t = 1.97 \text{ (significant at only the 90-per-cent confidence level)};$$

where Y is the average yield per acre (in hundred pounds) during a five-year period for eleven estates; and F is the average Lang's factor during the same period on the same estates. Data are from Karim and Khan [7, p. 732].

25 $$P_t = 2.151 + \underset{(1.529)}{16.994}\,X_{t-1};$$

$$n = 107;\ r^2 = 0.54$$

$$t = 11.12 \text{ (significant at the 99-per-cent confidence level)};$$

where P is monthly tea production (million pounds), 1952—60; and X is the ratio of monthly rainfall to average temperature for the same period. (We also tested a correlation using maximum temperature in the denominator, and it yielded essentially the same results.) Production data are from Table B-1 (CSO); rainfall data are from Table B-2; and temperature data are from Table B-7 and Table B-8. The temperature data are from the Srimangal Station in Sylhet District.

26 Technically, the ratio we used was not the Lang's factor, since our data for rainfall was in inches and for temperature, in degrees Fahrenheit. Although the Fahrenheit temperature in the denominator of the ratio yields slightly different results than centigrade (because a given change in temperature will be a larger percentage change if measured in centigrade), the monthly rainfall changes were so great that they would dominate the ratio regardless of which temperature measure was used in the denominator.

is due to the numerator or the denominator. If the Lang's factor *increases* due to an increase in rainfall (in the numerator), production *increases;* but if the factor *increases* due to a decrease in temperature during the winter months (in the denominator) production *decreases*. In addition, a pragmatic weakness in this factor should be noted. Changes in the amount of monthly rainfall explained 55 per cent of the variations in production in the following month; (the r^2 of 0.55 was reported above). Changes in the Lang's factor explain only the same degree of variation in production (the r^2 was 0.54), so the introduction of the temperature variable in this ratio adds nothing to the explanation of production variations previously attributed to rainfall alone. Due to these weaknesses, the Lang's factor is not a valuable tool in the analysis of tea production.

A second method of assessing the impact of both rainfall and temperature on production is by multi-variable regression analysis by which the relative importance of each variable can be isolated. We initially assumed that the amount of rainfall was the key variable and that this was modified by temperature movements, which might go too low in the winter or too high in the summer (*i.e.*, that the relationship between temperature and production is nonlinear). Therefore, we treated winter-minimum and summer-maximum temperatures separately, and also introduced combination variables (temperature times rainfall) in an attempt to test the interrelationship between these two variables. The results, however, were unsatisfactory and difficult to interpret, so they are not reported here[27].

One important conclusion emerging from this multiple regression, however, was that the amount of monthly rainfall was not a highly significant factor in explaining subsequent production. The probable reason for this is that, beyond a certain point, additional rainfall may be of little or no benefit to the tea plant, and we did not attempt to take account of this kind of nonlinearity. It has been estimated that in Ceylon, for example, forty-five inches of rainfall per year (about four inches per month) would be adequate for tea growing if it were well-spread throughout each month and over the year [5, p. 24]. Annual rainfall in Sylhet has averaged about 133 inches, but monthly rainfall ranges from practically zero to over forty inches; it is quite probable that rainfall above ten to fifteen inches in one month does little good, or at least is subject to diminishing returns. As one analyst has stated (in connection with a study of another crop):

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[27] The multiple regression related monthly production to five independent variables; rainfall, minimum temperature (of 60° Fahrenheit or less), maximum temperature (of 85 degree or more), and two combination variables, rainfall times minimum temperature, and rainfall times maximum temperature. For a detailed discussion, *see* [40, Appendix B].

> The recorded average rainfall cannot be used directly for analytical purposes as a portion of it is lost through run-off, drainage and evaporation. Sometimes, the rainfall in a month exceeds the waterholding capacity of the rootzones of crops, and to the extent that it does, it is of no use to crops [39, p. 567].

This declining marginal benefit from additional rainfall is particularly true in tea, where the plants are grown on rolling slopes to permit regular drainage and to facilitate the run-off of the heavy monsoon rains. In this case, the number of rainy days per month, reflecting the degree of regularity and distribution of rain, would be a better measure of "good rainfall" than the actual quantity of rain[28].

The Relationship between Production and the Number of Rainy Days

As in the case of rainfall, in the analysis of rainy days we investigated first the question whether high annual production is the result of a "good rainfall year," as measured by the number of rainy days. A test of the thirteen-year period, 1948-60, revealed no significant correlation [40, p. 9][29]; but, because of weaknesses in the data before 1951 (*see*, Appendix A and [37]), we fitted a second regression for the nine-year period, 1952-60, with highly significant results[30]. The r^2 was 0.83 and the output elasticity (with respect to rainy days) was 0.88. Obviously, the number of rainy days, reflecting indirectly both the spread and the quantity of rainfall, is a very important factor, if not the most important, explaining variations in tea production.

These positive results at the level of annual comparisons were followed by a retest of the hypothesis that rain in the relatively dry periods substantially affects production in the following season. For the nine-year period, 1952-60, we correlated the number of rainy days from October through February (the cool-dry period) with production for the overlapping calendar year January to December, and there was no significant relationship [40, p. 10][31]. The number of rainy days in the hot-dry period (March-April) and production in the subsequent season (May-December) were positively related (the r^2 was 0.44), but the out-

[28] For some crops, adjustment factors have been derived which can be applied to the actual monthly rainfall to estimate "maximum effective rainfall." *See* [39, p. 567].

[29] The rainy-day data are averages for the Sylhet district and are given in Table B-6.

[30]
$$P_t = 6.471 + \underset{(0.069)}{0.397}\, D_t;$$
$n = 9$; $r^2 = 0.83$;
$t = 5.75$ (significant at the 99-per-cent confidence level);
$E = 0.88$; $\bar{P} = 53.35$; $\bar{D} = 118.1$;
where P is annual production (million pounds) 1952—60; and D is the annual number of rainy days for the same period. $\bar{P}$ is the average P; $\bar{D}$ is the average D. Data are from Table B-1 (CSO) and Table B-6.

[31] As would be expected, a regression fitted to the data from 1948-60 also yielded no significant correlation.

put elasticity was low (0.19), and the correlation was significant at only the 90-per-cent confidence level[32]. This lends only modest support to the thesis that rainfall during the relatively dry period is of particular importance for production during the subsequent season.

On a month-to-month basis, however, rainy days and production are highly correlated as can be seen in Figure 3 which shows the average monthly production and rainy days as percentage deviations from their annual means. Changes in monthly production follow a pattern very similar to that of changes

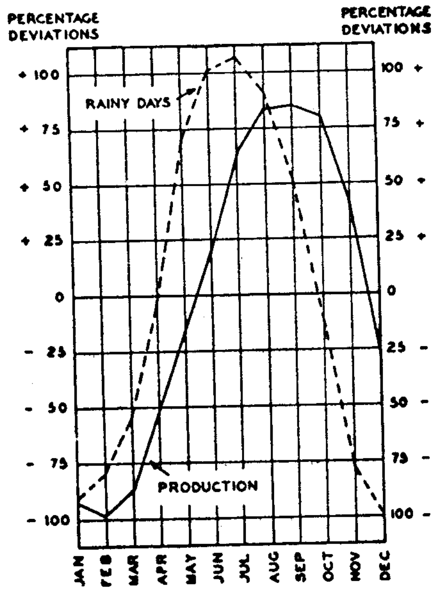

FIGURE 3. AVERAGE MONTHLY PRODUCTION AND RAINYDAYS, 1952–60
(PERCENTAGE DEVIATIONS FROM THE 108-MONTH MEANS)
SOURCE: PRODUCTION: TABLE B-1 (CSO)
RAINYDAYS : TABLE B-6

in the number of rainy days from one to three months earlier. Therefore, we fitted three regressions, testing the relationships between monthly production and the number of rainy days during the previous one month, two months, and

[32] $P = 40.267 + \underset{(0.318)}{0.745}\,D;$

$n = 9;\ r^2 = 0.44;$

$t = 2.34$ (significant at the 90-per-cent confidence level);

$E = 0.19;\ \bar{P} = 50.07;\ \bar{D} = 13.16;$

where P is production (million pounds) from May-December, during 1952-60; and D is the number of rainy days during March-April for the same period. Data are from Table B-1 (CSO) and Table B-6. A regression based on the data for the period 1949-60 was not significant.

three months[33]. The results are highly significant and are shown in summary form in Table X. Although the previous month's rainy days alone are important in explaining variations in monthly production ($r^2 = 0.76$), over 90 per cent of these variations were explained by the number of rainy days in the previous two months ($r^2 = 0.91$) and previous three months ($r^2 = 0.90$). Further, in both of these latter cases, the output elasticity was about 0.9, indicating that monthly

TABLE X

MONTHLY PRODUCTION AS A FUNCTION OF THE NUMBER OF RAINY DAYS

Rainy days in previous: (1)	r^2 (2)	E^a (3)	ΔP^b (in pounds) (4)
(1) One month (D_{t-1})	0.76	0.74	332,000
(2) Two months ($D_{t-1} + D_{t-2}$)	0.91	0.86	389,000
(3) Three months ($D_{t-1} + D_{t-2} + D_{t-3}$)	0.90	0.91	415,000

a) E is output elasticity with respect to the number of rainy days.
b) Δ P is the change in output resulting from a 10-per-cent change in the number of rainy days per month. Since the average number of rainy days is approximately ten, this is essentially the change in production associated with one more rainy day per month.

[33] (1) $P_t = 1.158 + \underset{(0.018)}{0.335} D_{t-1}$;
$n = 107$; $r^2 = 0.76$;
$t = 18.47$ (significant at 99-per-cent confidence level);
$E = 0.74$; $\bar{P} = 4.48$; $\bar{D} = 9.93$.

(2) $P_t = 0.632 + \underset{(0.006)}{0.195} (D_{t-1} + D_{t-2})$;
$n = 106$; $r^2 = 0.91$;
$t = 32.72$ (significant at 99-per-cent confidence level);
$E = 0.86$; $\bar{P} = 4.53$; $(\bar{D}_{t-1} + \bar{D})_{t-2} = 19.96$.

(3) $P_t = 0.402 + \underset{(0.004)}{0.137} (D_{t-1} + D_{t-2} + D_{t-3})$;
$n = 105$; $r^2 = 0.90$;
$t = 30.92$ (significant at the 99-per-cent confidence level);
$E = 0.91$; $\bar{P} = 4.56$; $(\bar{D}_{t-1} + \bar{D}_{t-2} + \bar{D}_{t-3}) = 30.31$.

P is monthly production (million pounds) 1952-60; and D is the number of rainy days per month during the same period. Data are from Table B-1 (CSO) and Table B-6. We also fitted a regression relating production to rainy days the same month:

$P_t = 2.238 + \underset{(0.030)}{0.224} D_t$;
$n = 108$; $r^2 = 0.34$;
$t = 7{\cdot}44$ (significant at 99-per-cent confidence level);
$E = 0.50$; $\bar{P} = 4.45$; $\bar{D} = 9.84$.

Although the correlation was highly significant, rainy days in the same month are not as important as in the previous month, as E was only 0.50, and r^2 was only 0.34.

production varied almost proportionately with the number of rainy days during the earlier two and three-month periods. A 10-per-cent change in the number of rainy days (approximately one day per month since the average number of rainy days is about ten per month) was followed on the average by a monthly production change (as shown in Table X, Column (4)) of 332,000, 389,000, and 415,000 pounds in the three cases. This is about 8 to 9 per cent of average monthly production, and 0.7 to 0.8 per cent of the average annual production.

In the light of these high correlations, we made another test of the impact of rainfall in the dry periods. We fitted a regression equation relating production in December, April, and May, and the previous two months' rainy days, October-November, February-March, and March-April[34]. These months were selected on the basis that they had light rainfall, and their temperatures were not too low to inhibit tea plant growth (as might be the case in the coldest winter months). This time the correlation was highly significant; and an additional day's rain per month was associated with a 396,000-pound change in output. Although, we have been unable to establish any substantial relationship between rain during the dry periods and production, throughout the subsequent season, there is a strong, positive correlation with production the following month.

From the standpoint of prediction the above regressions can be used to make estimates of "next month's" production, as soon as "this month's" rainy days are known. In order to make a projection for the "next two months", we tested the relationship between two months' rainy days ($D_{t-1}+D_t$) and the following two months production ($P_{t+1}+P_{t+2}$). and found a good correlation[35]. The r^2 was 0.91 and the output elasticity was 0.81; a 10-per-cent change (about two days) in the number of rainy days during a two-month period was followed by a 740,000-pound change in production the following two months (or about 370,000 per month). These results are quite consistent with those noted

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[34] $P_t = 1.098 + \underset{(0.036)}{0.198} (D_{t-1} + D_{t-2})$;

$n = 27$; $r^2 = 0.55$;
$t = 5.51$ (significant at 99-per-cent confidence level);
$E = 0.64$; $\bar{P} = 3.07$; $(\bar{D}_{t-1} + \bar{D}_{t-2}) = 9.93$;

where P is monthly production (million pounds) during December, April, and May, 1952-60; and D is the number of rainy days per month for the same period. Production data are from Table B-1 (CSO) and rainy-day data are from Table B-6.

[35] $(P_{t+1} + P_{t+2}) = 1.701 + \underset{(0.012)}{0.370} (D_t + D_{t-1})$;

$n = 105$; $r^2 = 0.91$;
$t = 31.58$ (significant at 99-per-cent confidence level);
$E = 0.81$; $(\bar{P}_{t+1} + \bar{P}_{t+3}) = 9.13$; $(\bar{D}_t + \bar{D}_{t-1}) = 20.10$;

where P is monthly production (million pounds) 1952-60; and D is the number of rainy days per month during the same period. Data are from Table B-1 CSO and Table B-6.

above and support the conclusion that in a simple bivariate correlation, an extra rainy day is assocated with about 350,000 to 400,000 pounds in subsequent tea output. The use ofthese regressions for purposes of estimation will be discussed below.

Tea Production, Rainy Days and Temperature

Although the number of rainy days is obviously a key factor affecting tea production, temperature movements undoubtedly have influenced the preceding results. As mentioned before, the tea plant becomes somewhat dormant during the cold winter months, which affects the relationship between rainy days and production. To test this aspect of the problem more precisely, we divided the year into two parts to isolate the warm summer months, when it was expected that changes in the number of rainy days would have the largest impact, from the cold winter months, when we assumed the relative dormancy of the tea plant would reduce the impact of variations in rainy days (and perhaps yield no significant correlation)[36]. The results of the two regressions, our expectations. For January, February, and March production, there was no statistically significant relationship with the number of rainy days in the preceding two months [40, p. 14]. For April through December, there was a high correlation with the previous two months' rainy days[37], and the test revealed that an extra rainy day per month was followed by an increase in tea production of 334,000 pounds[38].

Since rainy days and (mean) temperature follow a similar seasonal pattern increasing from December-January lows to June-August highs the change in tea production *associated* with an extra rainy day in the bivariate regressions is probably *caused* by a combination of more rain *and* higher temperature. Although thisbasic seasonal (mousoon) cycle is similar for both factors, rainy

[36] Harler [5, p. 28] reports that in Assam, for exaple, irrigation during the cool (dry) season fails to have a significani impact on tea production.

[37] $$Ps_t = 1.560 + \underset{(0.007)}{0.167} (D_{t-1} + D_{t-2});$$

$n = 81$; $r^2 = 087$;
$t = 23.9$ (significant at 99-per-cent confidence level) ;
$E = 0.73$; $\bar{Ps} = 5.81$; $(\bar{D}_{t-1} + \bar{D}_{t-2}) = 25.48$.

where Ps is monthly tea production (million pounds) April through December ; and D is the number of rainy days per month. The data pertain to 1952-60 and are from Table B-1 (CSO) and Table B-6.

[38] A similar regression based on five summer months when both production and rainy days are very high (June through October) revealed that one additioal rainy day per month was associated with only 300,000-pound increase in output. As noted above, a rainy day in the dry, but not too cold months had a greater impact (396,000 pounds) on production in December, April, and May. These results support the contention, based on classical diminishing returns, that during those months when rainfall is the heaviest, an extra day's rain conributes less to output than during other months. Even though the linear-regression equations show a good correlation between production and rainy days, the basic relationship appears to be somewhat nonlinear.

days and temperature do not always vary to the same extent, or even in the same direction, during any particular week or month. Therefore, the role of rainy days can be isolated by stating the monthly values of both rainy days and production as deviations from their monthly averages. For example, the November 1960, rainy-day value would be stated as —1.3, because during that month, there were 0.3 rainy days (the average for the reporting stations in the Sylhet district) whereas the average for November (1952-60) was 1.6 rainy days. This method removes seasonal changes (which are closely correlated with temperature movements) from both the production and rainy-day variables. It is then possible to assess to what extent an above-average number of rainy days was followed by above-average production (and *vice versa*).

We fitted a regression relating two months' production to the previous two month's rainy days, both stated as deviations from their nine-year means. Since production from January to March was unresponsive to changes in the number of rainy days, we confined our analysis to the remaining months, April through December[39]. The correlation was highly significant, and it revealed that if there were two more rainy days than the average for two months (or one extra rainy day per month), production in the following two months was 412,000 pounds above average (206,000 pounds per month). Stated in a more simple way, the increase in subsequent tea output from one extra rainy day was 206,000 pounds. This impact was just about half that (370,000 pounds) derived when actual production and rainy-day data were used, which suggests that approximately half of the impact *associated* with an extra rainy day in the previous bivariate regression[40] was caused by changes in other factors, such as inter-month differences in temperature.

The effect of temperature changes on production can be assessed by including it explicitly in the regression analysis. As can be seen in Figure 2 above,

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39 $(\dot{P}_t + \dot{P}_{t+1}) = 0.057 + \underset{(0.042)}{0.206} (\dot{D}_{t-1} + \dot{D}_{t-2});$

$n = 72; r^2 = 0.26;$

$t = 4.94$ (significant at 99-per-cent confidence level);

where $\dot{P}$ is monthly production, and $\dot{D}$ is the number of rainy days per month, both stated as deviations from the 1952-60 monthly means. The production months were April-May through November-December, and the rainy day months were February-March through September-October. The data are derived from Tables B-1 (CSO) and B-6. Since we have eliminated the important role of rainy days in determining the mean production each month and have concentrated here on the deviations from the means, we would naturally expect the coefficient of determination ($r^2 = 0.26$) to be lower in this case. In addition to the rainy days for these particular months ($\dot{D}_{t1}$ and $\dot{D}_{t-2}$), the production deviations are also caused by deviations in the temperature ($\dot{T}$ and $\dot{T}_{t-1}$, as shown below) and in rainy days of other months (such as $\dot{D}_t$, $\dot{D}_{t+1}$ and $\dot{D}_{t+3}$).

40 *See*, footnote 35 above.

changes in monthly production appear to follow changes in average temperature, with approximately a one-month lag. A regression relating production with temperature in the previous month revealed a high correlation with an r^2 of 0.77[41]. A one-degree change in temperature was associated with a change in production the following month of 354,000 pounds.

These results are very similar to the bivariate regression relating production and rainy days in the previous month (reported above) for which the r^2 was 0.76, and a change of one rainy day was associated with a change in production the following month of 335,000 pounds[42]. Clearly, both variables are important so we fitted a multiple regression relating both to monthly production[43]. The r^2 was 0.84, and the correlation revealed that an additional rainy day and an additional degree of temperature were followed by production increases of 182,000 and 195,000 pounds, respectively. The bivariate regressions "explained" monthly variations in production in terms of one factor only (first rainy days, and then temperature), and, because the two variables are highly interrelated the output response attributed to changes in each independently was about twice as high as that derived from the multivariate analysis including both factors simultaneously. The latter, of course, more accurately portrays the relative importance of changes in temperature and rainy days; it supports the conclusion of the previous deviations regression that, on the average, an extra rainy day contributes about 200,000 pounds to tea output the following month, and it indicates that a one-degree (Fahrenheit) increase in temperature has a comparable impact.

Although this correlation between production, on the one hand, and rainy days and temperature, on the other, is very high and statistically significant, it conceals certain interrelationships between temperature and rainfall which

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[41] $P_t = -22.565 + \underset{(0.019)}{0.354}\, T_{t-1};$

$n = 107;\ r^2 = 0.77;$

$t = 18.62$ (significant at 99-per-cent confidence level);

$E = 6.03;\ \bar{P} = 4.48;\ \bar{T} = 76.48;$

where P is monthly production of tea (million pounds) 1952-60; and T is the monthly average of the mean minimum and the mean maximum temperature (Fahrenheit) for the same period. Production data are from Table B-1 (CSO); temperature data are from Tables B-7 and B-8.

[42] *See*, equation (1) in footnote 33.

[43] $P_t = -12.352 + \underset{(0.026)}{0.182}\, D_{t-1} + \underset{(0.028)}{0.196}\, T_{t-1};$

$n = 107;\ r^2 = 0.84;$

$t_1 = 6.87;\ t_2 = 7.01$ (both significant at 99-per-cent confidence level);

$E_1 = 0.40;\ E_2 = 3.34;\ \bar{P} = 4.48;\ \bar{D} = 9.93;\ \bar{T} = 76.48$

where P is monthly tea production (million pounds) 1952-60; D is the rainy days per month; and T is the average of the monthly mean minimum and mean maximum temperatures. E_1 is the output elasticity with respect to rainy days. E_2 with respect to temperature. Production data are from Table B-1 (CSO); rainy-day data are from Table B-6; and the temperature data are from Tables B-7 and B-8.

have an important bearing on production in any particular month, and which, therefore, are strategic in making an accurate forecast of future production. The most important of these interrelationships is that in those summer months when rainfall is less than average, the temperature tends to rise above average. In April and May 1960, for example, rainfall was 7.92 inches and 5.13 inches below the average for those months (Table B-2), and the maximum temperature rose to 6.2 degrees and 5.2 degrees above the monthly averages (Table B-8). Many other examples could be given, and, of course, the opposite is also true: higher-than-average rainfall during the summer tends to cause lower-than-average temperatures. In such cases, production would probably tend to move directly with rainfall (as indicated by the deviations regression) and inversely with temperature changes, rather than vary directly with both, as indicated in the multiple regression above. Another interaction which is ignored by the form of this multiple regression is that in the winter, temperatures are sufficiently low that additional rain is not related to production the following month.

A different and more sensitive test has to be applied if these movements of temperature and rainfall, and their impact on production, are to be isolated. It was such a test that we attempted in the first multiple regression mentioned in the earlier section on rainfall and temperature, but that test was not successful. Future research can profitably be directed along these lines, testing the minimum and maximum temperatures beyond which production is adversely affected, and testing the interrelationships between temperature and rainy days. In addition, the precise nature of the time lag between the change in rainy days (and temperature) and the change in output should be explored more carefully, in order to isolate the relative importance of each month's rainy days (and temperature) on future output.

Short-run Fluctuations: Summary and Conclusions

In addition to delineating areas for further research (one merit of almost every study), this analysis of short-run fluctuations has yielded certain important conclusions.

i) The quantity of rainfall, in inches, was not closely related to production. At least, the relationship was not linear as the usual regression equations did not reveal a high correlation (and in the case of the multiple regression discussed in [40, Appendix B], the relationship was not highly significant).

ii) The Lang's factor (rainfall/temperature), which has been used by some analysts of tea production, was found to be conceptually weak, and the introduction of temperature in this way added nothing to the explanation of changes in tea output based on rainfall alone.

iii) During the relatively dry period, from October through April, two groups of months were distinguishable. Production in January, February, and March was not related to the number of rainy days during the preceding two months ($D_{t-1}+D_{t-2}$). This supports the thesis that the cold weather in December through February arrests the growth of the tea plant. However, production in December, April, and May was somewhat more responsive (396,000 pounds) to an additional rainy day per month than production for the nine summer months (334,000 pounds) or for the five very rainy summer months (300,000 pounds). This lends modest support to the thesis that rainfall in the not-too-cool dry months is of particular importance for subsequent production. Other tests failed to find any significant relationship between rainfall or rainy days in these dry months and production in the following season.

iv) There was a very high correlation between rainy days and tea production both on an annual and on a month-to-month basis. The r^2 was about 90 per cent when two month's rainy days were related to the following one month's production (for all twelve months and for the nine summer months) and to the following two months' production.

These results might be utilized for making estimates of production one to two months ahead. For example, the regression equation for the nine summer months, April through December (1952-60), was as follows:

$$Ps_t = 1.560 + 0.167\,(D_{t-1}+D_{t-2}).$$

Given the number of rainy days, this equation can be used to yield a series of "estimates" for monthly production, which would be within one *standard deviation of forecast* of the actual production 68 per cent of the time, and which would be within two (actually 1.96) standard deviations of the actual production 95 per cent of the time. If the number of rainy days were thirty during a two-month period, the *standard deviation of forecast* for the above regression equation would be 0.86 million pounds. Thus, the following month's production could be estimated as 6.57 ± 0.86 million pounds, or from 5.71 to 7.43 million pounds. A prediction made in this way would be correct 68 per cent of the time. Given thirty days of rain, the following month's production would be 6.57 ± 1.69 million pounds, or from 4.88 to 8.26 million pounds, 95 per cent of the time.

The above equation is based on the 1952-60 period, so some caution is required in applying it to future production. Expansion of acreage and the introduction of improved methods since 1960 have probably increased the responsiveness of production to changes in the number of rainy days. While this equation probably would yield approximate answers, it would be preferable to base estimates on a new regression for a more recent period, say 1959-64. (Complete data on rainy days after 1960 were not available in Karachi at the time of our study.)

Our regression for two months' production was as follows (for all months, 1952-60):

$$(P_t + P_{t+1}) = 1.701 + 0.370\,(D_{t-1} + D_{t-2}).$$

With thirty days of rain during a two-month period, the standard deviation of forecast would be 1.80 million pounds, so the following two months' production would be 12.80 ± 1.80 million pounds 68 per cent of the time, or 12.80 ± 3.53 million pounds 95 per cent of the time. The latter estimate yields a range from 9.27 to 16.33 million pounds for the following two-month period.

A somewhat better estimate can be made by using the deviations regression:

$$(\dot{P}_t + \dot{P}_{t+1}) = 0.057 + 0.206\,(\dot{D}^{t-1} + \dot{D}_{t-2}).$$

If there were thirty days of rain during April and May, this would be 4.4 days above the average of 25.6. The standard deviation of the forecast is 1.21 million pounds, so 95 per cent of the time the following June-July production would be + 0.91 ± 2.87 million pounds above the average June-July production of 12.66 million pounds. This yields a narrower range of estimate, 11.20 to 15.94 million pounds.

Although these regressions may be of some value for prediction, the range of all the estimates is quite wide, particularly for those at the 95-per-cent confidence level. The standard deviation was as low in these three cases as in any of the regressions reported in this study, so there is a definite limit to the usefulness of predictions of tea production based on the number of rainy days alone. As noted at the end of the previous section, better estimation will be possible only when there is a greater understanding of the interrelationships between rainy days and temperature, so that predictions can be based on both variables.

v) A change of one rainy day per month and a one-degree change in temperature appear, on the average, to be of almost equal importance for tea production the following month, both having an impact of about 200,000 pounds. Although perhaps little can be done to change temperature, the established importance of rainy days for increased tea production, throughout the period April through December, has significant implications for the possible expansion of irrigation on the tea estates. If an additional rainy—or irrigated—day causes subsequent production to increase by about 200,000 pounds, then, with a regularly operating irrigation system, possibly five to ten additional "rainy days" per month could be provided at critical times which might increase annual production by fifteen million pounds. This is approximately one-fourth of current yearly output (and at the average Chittagong auction price for 1963/64—Rs. 2.80 per pound [34]—this increase would be worth about forty million rupees). In combination with other improved methods (particularly fertilizer) and acreage expansion, the impact would be even greater.

Of course, tea irrigation is not a new idea, and in recent years experiments have been undertaken in East Pakistan testing the effect of applying water in different amounts and with a variety of timings[44]. Emphasis has been placed on irrigation in the dry months from February to May and the findings indicate that if the water application is sufficient to overcome the transpiration loss and to penetrate to the rootzones of the mature bushes, the season's output (at least on experimental plots) can be increased by more than 30 per cent [1, p. 91].

The present study indicates that irrigation even during the monsoon months would be productive. Although, there are many rainy days during the monsoon (averaging from 15 to 21 days per month) they are not always well distributed (in time or in area) and the actual rainy days are often two to six days below the average (*see,* Table B-6). The potential gains from irrigation during the dry periods of the monsoon appear to be very great; at least they are sufficiently large to justify further investigation of the costs and benefits of irrigating tea throughout the nine summer months.

IV: TEA PRODUCTION, CONSUMPTION, AND EXPORTS: 1964/65 TO 1969/70

We have reviewed and analysed certain basic characteristics of Pakistan tea production and consumption and there is no need to repeat the discussion here. However, it might be useful to indicate the implications of this study for the future, at least to the end of the Third Five Year Plan in 1969/70.

The production trend has been stagnant for twelve years through 1963 with an average production of about fifty-three million pounds. (As noted in Table II and Appendix A, different agencies have generated different figures, but the averages of most fall between fifty-two and fifty-four million pounds.) Since acreage under tea has expanded from about 78,000 acres in 1960 to 87,000 acres in 1964 (12 per cent)[45], some increase in production should be forthcoming soon. In fact, (although three years is much too short a period for calculating any significant trend), the average production of the past three years has been

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[44] The results of one of these experiments, and references to other articles on tea irrigation, are given by F. H. Abbasi and M. A. Mannan in [1]. *See also,* M. Habibullah [41, pp. 84-99] for a discussion of tea irrigation and other related matters.

[45] *See,* Table A-5 (PTB). Additional acreage expansion after 1964 will not have any significant effect on third-plan production, due to the long gestation period of the tea plant.

over fifty-five million pounds[46]. This might be an indication that past acreage expansion is beginning to have an effect. Assuming yields remain at the levels of recent years, total production in 1969/70 would be about fifty-nine million pounds.

From this perspective, the second-plan target of 63.8 million pounds and the third-plan benchmark of 62.0 million pounds, both of which relate to 1964/65, are extremely high and optimistic. Of course, if rainfall is heavy and well-distributed, it is conceiveable that production would exceed sixty million pounds this year; (it was almost this high in 1961). However, it would not represent a trend level or "benchmark" from which future output could be expected to rise.

A major question concerns the course of future yields. On the basis of the past trends, one might assume that yields will continue to fall, essentially offsetting the rise in area. On the other hand, recent efforts on the part of the industry, with the help of government, to improve methods, to expand the use of fertilizers, *etc.* should result in some increase in productivity. Further, the

[46] The annual fluctuations in tea production are so great that it is dangerous to draw any conclusions on the basis of only two or three years. The table below shows production on both a fiscal- and calendaryear basis for 1960-64. Since 1960 (and 1960/61) was a low-production year, averages of the first three or all four years are perfectly consistent with our conclusion that tea production has been stagnant. However, the average for the past three fiscal years has been 55.23 million pounds, and for the past three calendar years, 56.10 million pounds.

YEARLY TEA PRODUCTION

Fiscal Year	*Production*	*Calendar Year*	*Production*
1960/61	49,888	1960	42,508
1961/62	56,037	1961	59,940
1962/63	53,650	1962	52,516
1963/64	56,000	1963	55,845
	Averages		
	First Three Years:		
1960/61 to 1962/63	53,192	1960-62	51,655
	Four Years:		
1960/61 to 1962/63	53,893	1960-63	52,702
	Last Three Years:		
1961/62 to 1963/64	55,229	1961-63	56,100

Source: 1960-63: Table B-1 (CSO).
1963-64: [12].

expansion of area is gradually increasing the proportion of younger plants, from five to forty years of age, which are the most productive. On the basis of these considerations, it is reasonable to assume that yields will rise above their recent low level of 630 pounds per acre[47].

The third-plan target of 79.0 million pounds implies an average yield of 900 pounds (from the 87,000 acres which can be contributing to production in 1969/70). To reach this goal would require an increase in productivity per acre in excess of 40 per cent, a growth rate higher than that reported for nine of the eleven major tea-producing countries during the five-year period, 1954/55 to 1959/60 (*see*, Table VIII-B). Only for Russia and Argentina were higher growth rates reported, whereas for India and Ceylon, two of the largest producers, the increases in yields over the five years were only 8 and 18 per cent, respectively. Since yields in Pakistan have been declining for twelve years, it would be a major accomplishment if they were to increase by 20 per cent during the third-plan period, which would bring total production to sixty-five million pounds in 1969/70[48].

The Planning Commission now estimates that domestic demand in 1970 will be about sixty-five million pounds [28, p. 129], which is less than the level based on our analysis of the past trends. The absorption-trend values were 25.52 million pounds in 1951/52 and 50.69 million pounds in 1962/63, reflecting an average increase of 2.29 million pounds per year. A projection of this linear trend to 1969/70 yields an estimate of sixty-seven million pounds[49]. If, however, absorption is growing exponentially, rather than by the same amount each year, an estimate of seventy-eight million pounds is justified on the basis of the 6.3 per cent growth rate implicit in the increase in absorption during the past dozen years. Thus, if the forces shaping domestic tea absorption in the past are permitted to operate during the third-plan period, the level of absorption in 1969/70 would probably be between sixty-seven and seventy-eight million pounds. If the population is 129 million (*see*, Table B-9), this gives an estimated range for per-capita absorption of 0.52 to 0.60 pounds, which does not seem unrealistically high. Since the rate of growth of per-capita income is supposed to increase, unrestricted internal demand for tea would tend to rise at a more rapid rate than in the past, so that our estimated range is probably somewhat low.

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[47] This yield has been calculated on the basis of the trend production-figure of fifty-three million pounds. With an area of 83,700 acres in 1963, the yield was 630 pounds.

[48] This is based on a yield of 750 pounds for 87,000 acres.

[49] The trend value for 1962/63 of 50.69 and the "estimate" for 1963/64 of 53.29 (50.69 *plus* 2.29) are both less than the actual values reported for these years in Table III: 51.27 and 55.52, respectively. Thus, it appears that sixty-seven million pounds is a conservative estimate.

According to the *Outline of the Third Five-Year Plan:*

> The internal demand for tea by 1970 is expected to be around 65 million lbs. If the proposed target of 79 million lbs. for tea production is achieved, there may be an exportable surplus of 14 million lbs. [28, p. 129].

These are commendable targets, but the present analysis suggests that just the opposite results are possible: production of sixty-five million pounds; consumption of seventy-nine million pounds; and imports of fourteen million pounds! These results can only be prevented by radical changes of policy toward stimulating production and restraining consumption. Although this study has not focussed on policy solutions, it does indicate that, on the production side of the problem, irrigation might have a most important role to play.

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Appendix A

AN ANALYSIS OF THE TEA STATISTICS

To anyone who is working (or is planning to work) with data relating to tea (production, acreage, rainfall, *etc.*), a warning must be issued: for many of the figures in any one source, contradictory or conflicting figures can be found in another equally reputable source. The problem is not unusual; it can be found to some degree in all economic statistics in Pakistan and probably in all other countries. However, it is a serious problem in tea, so a careful analysis of the weaknesses and inconsistencies in the tea data may serve as a good example—a case study—with some relevance for the data in other areas of Pakistan's economic life.

There is no intention here of criticising those who are engaged in the most difficult task of collecting, organizing, and presenting statistics. Rather, our purpose is two-fold. *First,* the economic analysis of factors affecting tea production, given in the text, can be no better than the underlying data upon which it is based. Although we have tried to be objective in our investigation and cautious in drawing conclusions, the data are sufficiently conflicting that it is quite possible additional tests using alternative statistics would result in different conclusions. Therefore, one purpose of this appendix is to explain fully the types of problems and inconsistencies which exist so that the readers of this study in particular, and the users of tea data in general, may better understand and interpret the available statistics.

Second, this appendix is written in the hope that it will be of use to those who collect and organize the tea data. It will point up the confusion of the data user and it will show where the conflicts exist. With this information, it should be possible for those presenting the data to develop some modifications in their practices which might reduce these difficulties somewhat. (For example, one relatively simple "reform" which would resolve many of the problems discussed below would be more careful documentation: showing sources more fully, and including the precise date—or time period—to which the data apply.)

This appendix will be divided into sections dealing with the following types of data: production, rainfall, temperature, and acreage.

Production Statistics

Monthly data on tea production are regularly reported by several agencies including the Central Statistical Office (CSO), The Pakistan Tea Association (PTA), and The Pakistan Tea Board (PTB). The Central Statistical Office (CSO presumably receives its data from the Central Board of Revenue (CBR), which in turn, collects them from the excise officer's records at each tea estate. The PTA apparently, collects its data directly from the estate managers. For most years, the PTB figures co incide with those of the CSO, as both are based on the CBR excise-tax records, but for some years the PTB figures differ from the others. For example, Table A-1 shows the figures for 1959. For the January-April period, PTB reported production as 842,000 pounds greater than that of PTA and 185,000 pounds greater than that of CSO. In June, PTB figures are less than the other two by 3,000 pounds (PTA) and 20,000 pounds (CSO). Nor do the differences disappear in the annual totals for 1959. The PTB total is 582,000 pounds less than CSO and 849,000 pounds more than PTA.

The CSO monthly data were available for the period 1952-1963, and are shown in Appendix B, Table B-1. PTA monthly data are available from 1949-1962, but production in January-March is included with April in their presenta-

TABLE A-1

MONTHLY PRODUCTION OF TEA: 1959

Period (1)	CSO (2)	PTA (3)	PTB (4)
	(....................	*in thousand pounds*	.................)
January-April	3,927	3,270	4,112
May	4,638	4,573	4,574
June	5,709	5,692	5,689
July	8,456	8,338	8,350
August	8,700	8,621	8,622
September	8,954	8,938	8,938
October	7,730	7,600	7,600
November	6,310	6,154	6,150
December	3,547	3,354	3,354
Total	57,971	56,540	57,389

Sources: Column (2): Table B-1 (CSO).
Column (3): Table B-1 (PTA).
Column (4): [24, 1959-60].

tion (which is also given in Table B-1). A comparison of the figures yields differences analogous to those for 1959 given in Table A-1. For the January-April period, differences range from 10,000 and 48,000 pounds in 1961 and 1962, up to 668,000 pounds (1952) and 763,000 pounds (1954). For 1954, this difference amounts to about 25 per cent of the January-April production. Similarly, for other months, significant differences are to be noted. For example, in October 1953, CSO reports 706,000 pounds more production than PTA. (This is about 10 per cent of the output for that month.) Although the other monthly differences are less, many are in the range of 100,000 pounds to 400,000 pounds. Again as in the case of 1959, these monthly differences do *not* compensate each other: the annual totals are not the same. For all of these years, the PTA reports less annual production than the CSO: the divergences were 886,000 pounds in 1962, 1,584,000 pounds in 1956, and 1,870,000 pounds in 1952. (For 1952, this difference amounts to about 3.6 per cent of the annual production.)

Annual tea-production figures are also given by other agencies, such as the Ministry of Food and Agriculture (MFA) and the Central Board of Revenue (CBR). In Table A-2, MFA and CBR data are compared to those given by the CSO and the PTA[1]. The differences in the estimates are striking. In 1950/51, PTA reports annual production as 13.6 million pounds (36 per cent) larger than MFA; in 1959/60, MFA shows production as 7.19 million pounds (14 per cent) larger than PTA; and for 1960/61, the CSO gives production as 7.89 million pounds (19 per cent) above the MFA estimate. The differences between CSO and CBR data are particularly significant since the former shows the latter as its source. In 1956/57, the CBR reported production as 56.20 million pounds, 4.67 million pounds larger than CSO. In 1957/58, the difference was 3.59 million pounds, with CSO giving the larger figure of 51.20.

Conflicting data create a serious problem which hardly requires elaboration. Such differences cast doubt on the validity and meaning of all series, and raise questions concerning which figures should be used for economic analysis. However, there are two considerations which favour the use of the CSO data. *First*, and most important, production for all twelve months is given whereas PTA aggregates January-April production, and MFA gives only the annual totals. *Second*, the CSO is the official data-collecting agency of the government, and, unless there are good reasons for employing alternative statistics, those of the CSO should be utilized. For these reasons, the CSO production-figures

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[1] Since MFA and CBR figures are for the fiscal year, July to June, the annual production shown by the CSO and the PTA have also been adjusted to the July-June year. In tea there are three different "years" for which annual statistics are given: the calendar year, the production year (April to March), and the fiscal year. This is an additional hazard for the user of tea data.

TABLE A-2

ANNUAL PRODUCTION OF TEA IN PAKISTAN

Year (July-June)	MFA	PTA	CSO	CBR
(1)	(2)	(3)	(4)	(5)
	(......................*in million pounds*......................			)
1948/49	34.25	—	33.60	—
1949/50	38.88	48.25	38.08	—
1950/51	37.86	51.48	38.08	—
1951/52	47.13	52.98	53.76	—
1952/53	51.27	52.65	53.75	—
1953/54	52.02	54.29	55.92	55.38
1954/55	54.01	52.58	53.43	55.07
1955/56	52.63	54.72	56.03	54.15
1956/57	54.73	49.91	51.53	56.20
1957/58	44.50	49.94	51.20	47.61
1958/59	53.50	57.82	58.84	56.64
1959/60	57.00	49.81	50.76	50.86
1960/61	42.00	49.39	49.89	49.89
1961/62	58.80	55.06	56.04	56.04
1962/63	52.00	—	53.65	53.66
1963/64	55.00	—	56.00	—

Dash (—) means not available.

Sources: Column (2): 1948/49 through 1960/61, [22].
1961/62 and 1962/63, [21].

1963/64, [19]. Slightly different figures are given in [18, p. 187].
1957/58 - 44.63; 1960/61 - 42.25; and 1961/62 - 60.00.

Column (3): Table B-1 (PTA).

Column (4): 1948/49 to 1962/63, Table B-1 (CSO): 1963/64 [12].

Column (5): [10].

are generally used in this study, although on several occasions other figures are also utilized.

Rainfall Statistics

Monthly rainfall in the Sylhet district from 1948-1961 is presented in Table B-2. The figure given for each month is presumably a simple average of the amounts reported by the several meteorological stations. Although there are fourteen stations in Sylhet district[2], reports from all of them are not available in the Karachi office of the Meteorological Department. For some months reports from as few as three stations are recorded, while at the most, reports from eleven stations are available.

The details for the reporting stations for two years (1949 and 1960) are shown in Tables B-3 and B-4. For 1949, the number of reporting stations is eleven, and, apparently, the average of these eleven is given in Table B-2, as the figure for the Sylhet district as a whole. Only for two months do the figures diverge, and the differences are slight: 0.16 inch in July and 0.01 inches in September. For 1960, however, the differences between average rainfall in Sylhet district (Table B-2), and the average of the reporting stations (Table B-4) are very great. Only for three months (January, November, and December) are they identical, and the divergence is substantial for several of the other nine months, as shown in Table A-3. The largest difference is in September, for which the Sylhet-district average is 30.93 inches higher than the average of the reporting stations.

TABLE A-3

MONTHLY RAINFALL IN SYLHET: 1960

	May	July	September
	(.................	in inches	.................)
1) Sylhet district	16.72	43.98	42.86
2) Average of reporting stations	11.72	23.83	11.93
3) Difference (1-2)	5.00	20.15	30.93

Sources : Row 1: Table B-2.
Row 2: Table B-4.

Since the stationwise breakdown for 1960 gives reports from only a few (three to six) stations, it is quite possible that the Sylhet-district average (Table B-2) includes more stations than are given in the breakdown of Table B-4. While

[2] The fourteen stations are Sylhet, Lalakhal, Samanbagh, Maulvi Bazar, Manumakha, Chandbagh, Lungla, Kamalganj, Bangaon, Chandpur Bagan, Baikunthapur, Sunamganj, Srimangal, Habiganj.

this may be the general explanation for the divergence, it is not the case for several of the individual figures. In particular, the July and August figures, 43.98 inches and 14.63 inches, given for the Sylhet district (Table B-2), are identical to the figures given for the Sylhet station in the detailed breakdown of Table B-4. It seems likely that, in this instance at least, an error has been made in listing the rainfall at the Sylhet station as the average of all the reporting stations in Sylhet district[3].

If rainfall were spread quite evenly over the district, the average for the district as a whole would not be seriously affected by the absence of reports from some of the stations. Obviously, this is not the case in Sylhet, where interstation differences are considerable (Table B-4). For example,in October 1960, 1.32 inches were recorded by the station at Sylhet, while 11.42 inches fell at Baikunthapur. In July of the same year, Sylhet recorded 43.98 inches whereas only 15.88 inches were reported by Habiganj. Because of these divergences, the figure for average rainfall in Sylhet district might be changed significantly by the inclusion of rainfall at the nonreporting stations.

Even if the average rainfall was based on all fourteen stations, however, the important fact remains that in every month the rainfall at a large number of estates diverges substantially from the average, and that production on each and every tea estate depends on its own rainfall, not on the average for the district as a whole. These difficulties can only be surmounted with accurate data on production and rainfall (and temperature) for each and every estate.

While these data problems on rainfall are important, they should not be overestimated. For most months, reports from over half of the stations seem to have been included in the average given in Table B-2, so that it should generally approximate the average of all fourteen stations. Further, although there are substantial interstation differences for any given month, the month-to-month rainfall changes are similar, reflecting the winter "draught", summer "monsoon" pattern[4]. Consequently, changes in the average monthly rainfall probably reflect the changes in the various areas within the district, even though the levels of rainfall are substantially different. Such changes in the average district rainfall can then be meaningfully correlated with changes in monthly production.

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[3] Also the Sylhet-district figure for October 1960, 3.74 inches, is identical to that of one reporting station, Lallakhal, and is substantially below the average of 6.70 for the six reporting stations. Perhaps the Lalakhal figure has been mistakenly given for the district average.

[4] In 1949, for example, there are 121 rainfall changes shown in Table B-3. (There are eleven changes for each of the eleven reporting stations.) In all but fourteen of the 121 cases, the direction of the monthly change is the same as that of the majority of the reporting stations.

More accurate and complete data would certainly be desirable and will undoubtedly become available in the course of time. However, in the present study, the monthly rainfall figures given in Table B-2 have been used. To the extent that they do not accurately reflect the average rainfall and to the extent that changes in the average do not reflect changes throughout the district, the conclusions drawn will require modification.

The data on the number of rainy days probably suffers from similar weaknesses. However, we simply used the data given in [31], and [32], and did not look for alternative (and possibly conflicting) figures.

Temperature Statistics

The temperatures in Sylhet district also vary from one area to another, which raises problems analogous to those of rainfall discussed above. The 1959 and 1960 figures for two stations, Sylhet and Srimangal, are given in Table A-4. While in general the temperatures approximate each other and usually change in the same direction, some differences should be noted. In 1960, the Srimangal maximum temperature range was from 80.0 to 98.5 (18.5 degrees), compared to Sylhet's range of 77.8—92.7 (14.9 degrees). From February to March (1960), the Srimangal maximum temperature fell by 0.1 degree, whereas the Sylhet maximum rose by 2.0 degrees. (For three of the eleven changes in 1960 the maximum temperatures moved in opposite directions.) The 1960 minimum temperature ranges were 44.9—77.8 (32.9 degrees) in Srimangal and 53.6—78.1 (24.5 degrees) in Sylhet. The range at Srimangal, for both minimum and maximum temperatures, exceeds that of Sylhet by about 30 per cent.

The 1959 figures yield a similar pattern—a difference in the range, and slightly divergent movements for one or two months. Consequently, the temperature at one station or an average temperature for the district will not correctly reflect the temperatures in the various areas of the district. However, only for Srimangal were we able to get data for a substantial period of time (1948-60) and consequently this was utilized in the present study (*see*, Tables B-7 and B-8). To the extent that it does not adequately reflect changes in other parts of the district, the conclusions reached will have to be modified.

Acreage Statistics

Five estimates of tea acreage are given in Table A-5. As in the case of production statistics, the estimates differ, but only for four years are the differences marked. In 1950, the PTA gives a figure of 78,770 acres, which is over 4 per cent larger than the 74,900 estimate of the MFA and the Directorate of Agriculture, East Pakistan. In 1955, the difference between the figures of the Directorate (76,500) and the PTB (73,960) is about 3.5 per cent. In 1951 and 1953,

TABLE A-4

COMPARISON OF TEMPERATURES AT SYLHET AND SRIMANGAL STATIONS

Month	1959				1960			
	Mean minimum		Mean maximum		Mean minimum		Mean maximum	
	Sylhet	Sri-mangal	Sylhet	Sri-mangal	Sylhet	Sri-mangal	Sylhet	Sri-mangal
	(........................*in degrees Fahrenheit*........................)							
January	54.3	47.9	78.2	77.4	53.6	44.9	77.8	80.0
February	55.9	50.2	79.1	80.1	58.9	51.4	84.1	87.8
March	64.3	60.4	84.5	89.3	62.7	58.6	86.1	87.7
April	71.7	69.0	89.1	92.2	73.3	70.7	91.3	98.5
May	72.3	71.9	90.2	91.0	74.0	74.9	92.7	96.2
June	76.1	78.1	87.7	89.7	76.8	76.2	88.9	90.7
July	77.4	76.7	87.1	90.5	76.6	77.0	86.7	88.0
August	77.7	76.6	85.7	89.9	78.1	77.8	87.9	91.8
September	76.2	75.5	85.8	88.0	76.6	75.8	88.6	89.4
October	71.9	70.9	86.8	85.7	72.9	70.7	88.1	89.0
November	62.3	56.7	82.6	84.0	—	58.5	83.5	83.9
December	57.0	50.1	78.7	80.7	—	51.8	80.3	80.8

Dash (—) means not available. *Source*: [17].

the difference is about 3 per cent, and it is less than this in the remaining years covered.

In addition to these differences, however, there are also some year-to-year changes which are conflicting. From 1948 to 1949, the Directorate shows an acreage increase, whereas PTA shows a decrease. Just the reverse is true in 1951/1952; the Directorate records a decrease, whereas PTA and PTB report increases; (this same divergence exists in 1953/54 and 1955/56).

There are several possible reasons why the estimates differ. *First*, as noted in the text, "at the time of Partition no accurate statistics of area under tea of those gardens which then fell into Pakistan were available and it was not until 1951 that tea estates were called upon to submit details of their acreage under tea, etc., to government. [37]". This may explain completely the difference for 1948-1950.

Second, according to the judgement of the Secretary, PTA, the conflicting figures are "largely due to the period covered by the Reports of the Agricultural Department differing from the period covered by the Pakistan Tea Association and the Pakistan Tea Board" [37]. Both the PTA and the PTB estimates are as

TABLE A-5

TEA ACREAGE IN PAKISTAN

As on 31st March	MFA	PTB		PTA	Directorate of Agriculture, E. Pakistan
		Letter	Annual Reports		
(1)	(2)	(3)	(4)	(5)	(6)
	(..............................*in thousand acres*..............................)				
1948	73.20	—	—	75.06	73.20
1949	74.30	—	—	74.36	74.30
1950	74.90	—	—	78.77	74.90
1951	74.70	72.54	—	72.91	74.70
1952	73.46	72.93	—	73.27	73.46
1953	75.00	73.08	—	73.38	75.00
1954	74.18	73.60	—	74.36	74.17
1955	76.78	73.96	—	74.78	76.50
1956	76.28	74.89	—	75.05	76.00
1957	76.22	75.45	75.94	75.94	75.95
1958	75.95	76.50	76.67	76.67	75.95
1959	78.00	77.31	77.31	77.31	76.00
1960	78.26	78.16	76.91	77.55	—
1961	78.89	78.89	—	78.30	—
1962	81.00	80.70	—	79.87	—
1963	84.00	83.70	—	81.94	—
1964	—	87.00	—	—	—

Notes: *a*) Dash (—) means not available.
b) 1948-1959, "Registered Acreage"; 1960-1964, "Area under Tea."

Sources: Column (2): 1948—1961, [18, p. 110]; 1962/63, [19]. Figures are given for fiscal or tea season year (*i.e.*, 1963/64); they have been listed here under March 31st of the first year (*i.e.*, 1963).
Column (3): 1951—1963, [25]; 1964, [26].
Column (4): [24].
Column (5): 1948—1962, [35, 36]; 1963, [37].
Column (6): [30]. Figures are given for the tea season, April-March. They have been listed here under March 31st of the first year, as in the case of Column (2).

of March 31st of each year. It is not clear exactly what period (or date) is the basis for the acreage estimates given by the others. The Directorate of Agriculture in East Pakistan relates the figures to the tea or fiscal year (*i.e.*, 1959/60) as does the CSO in its Statistical *Yearbook* [13] and the same is true for the Ministry of Food and Agriculture. This procedure has increased the confusion surrounding the acreage estimates, since the fiscal-year estimates given are much closer to the PTA and PTB figures for the preceding March 31st than they are to the figures for the March 31st which falls within the fiscal year. Because of this in Table A-5 the fiscal-year figures of Columns (2) and (6) have been stated as of the preceding March 31st. However, as suggested by the Secretary, PTA, a different date or period than March 31st may have been used which would explain the divergence. Perhaps, the agencies involved will clarify this in the near future.

None of these reasons explain the differences between the estimates of the PTA and the PTB; although the differences are not very large, in only three years are the two series identical and for two of these years the PTB's two sets of figures are not the same. While the acreage trends since 1951 are essentially the same in all series, the year-to-year differences in both the magnitude and direction of change are sufficient to seriously weaken (if not undermine) any analysis of the short-run relationship (month to month, or year to year) between acreage and production.

There is, however, an even greater difficulty in using the acreage data, particularly for short-run analysis. Through 1959, the acreage figures reported by the PTA and the PTB were for "Registered Acreage" whereas since 1960, the acreage reported is for "Area under Tea". "The system of registering acreage which had obtained under the International Tea Agreement was changed in 1960 by the Pakistan Tea Board, and there was a considerable departure from what was originally termed 'Registered Acres' which included areas lying fallow for replanting [36, Appendix B]." "Registered acreage was the limit up to which the tea planters were permitted to plant [25]," and it exceeds by about 2 to 3 per cent [37] the new concept, "Area under Tea," which "means the actual area under plantation [25]." Since annual changes in the actual area probably did not exactly parallel changes in the registered acreage, the figures on the latter can not be used for an accurate assessment of the impact of changes in acreage on production (although for long-term trends, the figures on "Registered Acreage" can probably be used to reflect "Area under Tea").

A final problem to be noted is that, given acreage, production is heavily influenced by the age distribution of the tea plants. The tea plant usually produces very little for three to five years, is most productive between the ages of five and forty years, and declines in productivity after that time [2, p. 483; 4, p. 5; 7, p. 727] [5]. The age distribution in 1963 is shown in Table A-6, and the importance

TABLE A-6

AGE DISTRIBUTION OF TEA PLANTS: 1963

Age (years)	Acres	Per cent of total
0-5	10,676	13.0
5-40	29,097	35.5
40-60	24,472	29.9
Over 60	17,690	21.6
Total area under tea (excluding seed baris and nurseries)	81,935	100.0

Source: [37].

of the various categories can be easily seen. Only slightly over one-third of the acreage is under plants in their most productive years, and over half (51.5 per cent) of the plants are over forty years of age. Unfortunately, the tea age distribution is available only for the past few years, so that it can not be meaningfully utilized in an analysis of production. When accurate and complete figures are available for the total area and for the age distribution, a sounder analysis can be undertaken.

5 A recent study of some tea gardens in the Sylhet district revealed that the youngest garden (43 years old) had the highest yield per acre (1,381.62 pounds) whereas the oldest garden (84 years old) had the lowest yield (248.73 pounds) [7, p. 726].

Appendix B

TABLE B-1

PRODUCTION OF TEA IN EAST PAKISTAN

Month	1948		1949		1950		1951	
	CSO	PTA	CSO	PTA	CSO	PTA	CSO	PTA
	(in thousand pounds)							
January	—	—	—	—	—	—	—	—
February	—	—	—	—	—	—	—	—
March	—	—	—	—	—	—	—	—
April	—	—	—	—	—	—	—	—
Total: January-April	—	—	—	2,485	—	3,401	—	2,885
May	—	—	—	2,449	—	3,883	—	3,565
June	—	—	—	5,896	—	5,478	—	5,500
July	—	—	—	5,953	—	7,426	—	7,303
August	—	—	—	7,789	—	8,272	—	7,895
September	—	—	—	6,399	—	7,628	—	7,923
October	—	—	—	7,366	—	7,786	—	7,571
November	—	—	—	5,128	—	6,118	—	6,617
December	—	—	—	2,850	—	2,296	—	3,456
Total	44,454	43,792	47,069	46,316	53,247	52,288	53,435	52,718

(continued)

TABLE B-1—*contd.*

PRODUCTION OF TEA IN EAST PAKISTAN

Month	1952		1953		1954		1955		1956		1957	
	CSO	PTA	CSO	PTA	CSO	PTA	CSO	PTA	CSO	PTA	CSO	PTA
	(............					*in thousand pounds*						............)
January	466	—	232	—	338	—	303	—	391	—	322	—
February	103	—	61	—	157	—	—	—	35	—	103	—
March	530	—	1,378	—	852	—	234	—	589	—	589	—
April	2,177	—	2,437	—	2,386	—	2,524	—	3,088	—	1,076	—
Total: January-April	3,276	2,608	4,108	3,694	3,733	2,970	3,061	2,658	4,103	3,614	2,090	1,573
May	4,445	4,159	4,540	4,559	4,459	4,354	3,076	2,907	4,262	4,189	3,093	3,054
June	5,552	5,450	5,229	5,334	5,905	5,808	5,584	5,514	5,704	5,485	4,210	3,950
July	7,571	7,194	8,405	8,039	7,828	7,723	7,048	6,737	7,428	7,355	7,044	7,008
August	8,276	7,905	7,558	7,537	8,532	8,496	7,738	7,830	8,411	8,237	6,687	7,637
September	7,466	7,285	8,496	8,275	8,464	8,585	7,668	7,699	8,322	8,182	8,844	7,770
October	8,268	8,111	7,848	7,142	8,046	7,894	7,938	7,715	8,222	8,240	8,003	7,049
November	5,512	5,261	6,215	6,633	5,876	5,890	7,634	7,834	6,440	6,361	5,111	5,542
December	2,780	3,303	3,306	3,530	2,959	2,910	3,931	3,617	3,313	2,958	2,538	2,900
Total	53,146	51,276	55,705	54,743	55,802	54,630	53,678	52,511	56,205	54,621	47,620	46,483

(*continued*)

TABLE B-1—*contd.*

PRODUCTION OF TEA IN EAST PAKISTAN

Month	1958		1959		1960		1961		1962		1963	Average 1952—1960	
	CSO	PTA	CSO	PTA	CSO	PTA	CSO	PTA	CSO	PTA	CSO	CSO	PTA
	(........						*in thousand pounds*						........)
January	407	—	366	—	493	—	386	—	356	—	341	369	—
February	87	—	157	—	87	—	88	—	36	—	63	99	—
March	510	—	549	—	416	—	686	—	314	—	433	627	—
April	2,348	—	2,855	—	861	—	3,075	—	1,241	—	1,854	2,195	—
Total: January-April	3,352	2,592	3,927	3,270	1,857	1,630	4,235	4,225	1,947	1,899	2,691	3,279	2,734
May	4,227	4,088	4,638	4,573	730	748	3,974	3,967	4,007	3,944	3,827	3,719	3,626
June	5,394	5,353	5,709	5,692	4,476	4,429	6,234	6,184	4,586	4,549	5,156	5,307	5,224
July	8,198	8,329	8,456	8,338	4,249	4,181	8,334	8,205	7,020	6,905	8,247	7,358	7,212
August	8,943	8,553	8,700	8,621	6,907	6,912	9,625	9,467	8,995	8,894	9,027	7,972	7,970
September	8,404	8,405	8,954	8,938	7,240	7,109	9,207	9,055	8,356	8,104	8,206	8,206	8,028
October	8,385	8,779	7,730	7,600	7,837	7,798	8,713	8,590	7,829	7,806	8,321	8,031	7,814
November	6,684	6,434	6,310	6,154	5,979	5,923	6,815	6,630	6,627	6,485	6,856	6,196	6,226
December	3,950	3,791	3,547	3,354	3,233	3,092	2,803	2,719	3,149	3,044	3,514	3,284	3,273
Total	57,537	56,324	57,971	56,540	42,508	41,822	59,940	59,042	52,516	51,630	55,845	53,352	52,107

Dash (—) means not available.

Sources: CSO data from [12]; PTA data from [35] and [36].

TABLE B-2

MONTHLY AND ANNUAL RAINFALL IN SYLHET DISTRICT: 1948-61

Month \ Year	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	Average 1948-61	Average 1952-60
	(in inches)															
January	0.26	0.06	0.50	0.02	0.12	0.30	1.02	0.12	0.34	2.08	0.82	1.53	0.00	0.00	0.51	0.70
February	2.45	0.42	2.50	0.00	0.02	0.75	2.41	0.08	0.00	1.74	4.57	1.35	0.00	0.61	1.21	1.21
March	2.60	2.58	4.71	2.84	3.10	7.74	2.05	6.45	7.17	0.33	1.21	7.46	3.09	8.12	4.25	4.29
April	15.43	20.68	7.02	11.03	6.19	8.93	9.12	10.68	9.04	6.23	12.03	7.06	1.50	6.94	9.42	7.86
May	28.87	15.96	14.99	15.68	20.81	26.16	15.30	13.74	30.33	34.86	26.66	21.92	16.72	23.85	21.85	22.94
June	28.55	34.41	24.06	22.81	13.74	26.64	28.35	21.93	40.10	28.99	33.67	40.96	19.51	36.25	28.57	28.21
July	18.15	20.68	15.65	20.16	27.32	15.32	19.13	15.43	27.49	17.62	10.89	18.76	43.98	19.55	20.72	21.77
August	21.77	19.47	25·41	19.78	16.04	14.07	19.04	17.41	20.39	20.60	25.45	14.98	14.63	19.82	19.20	18.07
September	15.93	18.28	8.46	12.92	14.91	21.63	14.39	12.51	11.64	14.42	17.95	15.64	42.86	18.41	17.14	18.50
October	3.97	9.76	9.42	17.28	10.01	8.10	6.88	3.17	4.13	5.24	15.33	14.34	3.74	5.31	8.33	7.88
November	1.09	0.33	4.13	0.94	2.92	0.71	0.00	6.39	4.49	0.00	0.83	0.00	0.60	0.07	1.61	1.77
December	0.02	0.00	0.00	0.03	0.00	0.00	0.01	—	0.61	0.00	0.66	0.00	0.00	0.00	0.10	0.16
Annual total	139.14	142.63	116.85	123.49	115.18	130.35	117.70	107.91	155.73	132.11	150.07	144.00	146.63	138.93	132.91	133.30
Monthy average	11.60	11.89	9.74	10.29	9.60	10.86	9.81	8.99	12.98	11.01	12.51	12.00	12.22	11.58	11.08	11.11

Dash (—) means not available.

Sources: [31 and 32].

TABLE B-3

MONTHLY RAINFALL IN SYLHET DISTRICT—BY STATIONS: 1949

Station \ Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	(.....................					*in inches*						.....................)
Sylhet	0.00	0.48	4.12	23.71	14.30	62.27	21.40	30.98	21.14	15.23	0.60	0.00
Lallakhal	0.00	0.00	2.10	42.90	20.84	95.00	29.44	53.60	32.10	13.54	0.00	0.00
Samanbagh	0.06	0.10	1.90	13.68	13.08	17.64	18.40	14.26	9.85	6.53	0.58	0.00
Maulvi Bazar	—	—	—	—	—	—	—	—	—	—	—	—
Manumakh	0.00	1.85	2.32	25.90	15.30	26.10	6.55	2.20	—	—	—	—
Chandbagh	0.04	0.00	2.02	17.54	17.11	25.78	24.29	20.74	21.52	9.18	0.00	0.00
Lungla	0.10	0.00	1.23	18.20	13.75	19.70	23.64	15.63	17.11	6.50	0.00	0.00
Kamalganj	—	—	—	—	—	—	—	—	—	—	—	—
Bangoon	—	—	—	—	—	—	—	—	—	—	—	—
Chandpurbagan	0.07	0.79	4.60	15.60	18.82	20.53	12.68	9.34	13.24	7.21	0.69	0.00
Baikunthapur	0.00	0.80	3.67	14.47	15.37	19.90	12.95	12.39	7.74	11.38	0.36	0.00
Sunamganj	0.10	0.12	0.34	22.04	18.07	42.10	46.80	27.38	30.34	11.21	0.03	0.00
Sri Mangal	0.23	0.06	3.03	16.11	11.99	25.06	11.70	9.50	12.45	6.66	0.18	0.00
Habiganj	0.02	0.35	3.08	17.35	16.93	24.39	17.87	18.15	17.32	10.10	0.87	0.00
Average	0.06	0.41	2.58	20.68	15.96	34.40	20.52	19.47	18.28	9.75	0.33	0.00

Dash (—) means not available.

Source: [16].

TABLE B-4

MONTHLY RAINFALL IN SYLHET DISTRICT BY STATIONS: 1960

Station \ Month	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
	(in inches)											
Sylhet	0.00	—	2.82	0.78	13.58	17.28	43.98	14.63	25.49	1.32	—	0.00
Lallakhal	—	—	—	—	—	—	—	—	—	3.74	—	—
Samanbagh	—	—	—	—	—	—	—	—	—	—	—	—
Maulvi Bazar	—	—	—	—	—	—	—	—	—	—	—	—
Manumakh	—	—	—	—	—	—	—	—	—	—	—	—
Chandbagh	0.00	0.00	2.60	—	—	—	—	—	—	—	—	—
Lingla	—	—	—	1.16	9.18	21.63	18.76	10.33	14.34	—	—	—
Kamalganj	—	—	—	—	—	—	—	—	—	—	—	—
Bangoon	—	—	—	—	—	—	—	—	—	—	—	—
Chandpurbagan	—	—	—	2.68	—	15.66	—	12.15	18.90	9.24	0.00	0.00
Baikunthapur	0.00	0.65	2.45	2.10	12.41	18.68	16.76	—	19.92	11.42	1.80	0.00
Sunamganj	—	—	—	—	—	—	—	—	—	—	—	—
Srimangal	0.00	0.00	2.31	1.74	—	23.01	—	—	13.73	6.00	—	0.00
Habiganj	—	—	—	0.00	—	16.72	15.83	9.86	21.19	8.46	0.00	—
Average	0.00	0.22	2.54	1.41	11.72	18.83	23.83	11.74	11.93	6.70	0.60	0.00

Dash (—) means not available.

Source: [16].

TABLE B-5

ANNUAL PRODUCTION AND RAINFALL (BY CIRCLES)[a] (1959—1962)

Circle	1959		1960		1961		1962	
	Production	Rainfall	Production	Rainfall	Production	Rainfall	Production	Rainfall
	(......Production in million pounds and rainfall in inches......)							
North Sylhet	4.80	228	4.58	136	5.25	167	4.88	149
Juri Valley	8.52	131	6.62	90	8.75	92	8.01	106
Lungla Valley	8.16	119	6.59	90	8.48	93	7.23	92
Manu-Doloi	7.75	104	5.73	85	8.56	86	8.10	99
Balisera	14.67	100	9.78	86	15.44	83	12.82	93
Luskerpore	10.33	95	6.82	91	10.55	74	8.50	90
Chittagong	2.30	115	1.69	101	2.02	129	2.08	85

a) Circles are administrative units in East Pakistan.

Source: [36, Appendices B and F].

TABLE B-6

AVERAGE NUMBER OF RAINY DAYS (SYLHET DISTRICT)

Month	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	Monthly average 1948-60	Monthly average 1952-60
January	0.4	0.3	1.5	0.1	0.2	1.6	0.3	0.6	0.8	2.9	0.0	2.5	0.0	0.9	1.0
February	4.6	0.8	2.9	0.0	0.1	0.8	2.8	1.0	0.0	2.2	6.5	3.0	1.0	2.0	1.9
March	3.6	3.8	4.9	4.2	5.5	8.7	2.6	6.7	8.0	0.3	0.7	7.3	4.0	4.6	4.9
April	13.5	17.4	6.4	12.8	8.7	8.6	11.9	10.0	8.9	6.6	10.0	6.4	3.7	9.6	8.3
May	21.2	15.7	14.8	15.7	18.3	17.6	17.7	12.9	21.2	15.2	17.3	19.6	15.7	17.1	17.3
June	21.5	21.1	19.8	19.8	17.6	21.7	23.6	21.7	23.4	21.6	19.4	19.9	12.3	20.3	20.1
July	22.0	22.1	20.2	19.7	22.8	19.0	20.4	2 0.4	21.5	18.8	20.8	20.8	23.0	20.9	20.8
August	22.1	18.6	24.7	20.6	21.9	17.4	16.3	22.5	20.1	14.6	21.2	18.8	11.7	19.3	18.3
September	18.2	18.9	12.0	10.8	18.4	17.4	15.7	14.2	13.6	13.4	14.2	14.0	18.5	15.3	15.5
October	6.6	8.4	11.2	12.8	8.6	8.3	8.5	7.0	7.3	5.0	10.0	13.5	5.5	8.7	8.2
November	2.6	0.7	2.4	1.4	4.8	2.4	0.0	4.4	2.5	0.0	0.3	0.0	0.3	1.7	1.6
December	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.9	0.0	0.5	0.0	0.0	0.1	0.2
Annual rainy days	136.4	127.8	120.8	118.1	126.9	123.5	119.8	121.4	128.2	100.6	120.9	125.8	95.7	120.5	118.1
Monthly average	11.4	10.6	10.1	9.8	10.6	10.3	10.0	10.1	10.7	8.4	10.1	10.5	8.0	10.0	9.8

Sources: [31 and 32].

TABLE B-7

MEAN MINIMUM TEMPERATURE (Srimangal Station)

Month \ Year	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	Average 1948-60
	(......						*in degrees Fahrenheit*							......)
January	49.5	47.8	47.1	45.8	48.2	45.8	44.2	45.8	46.5	49.6	49.5	47.9	44.9	47.1
February	54.3	50.8	53.2	49.6	53.1	52.1	55.3	46.7	46.9	51.1	52.3	50.2	51.4	51.3
March	61.2	63.0	60.7	62.5	59.5	67.0	58.9	61.5	62.5	57.2	58.4	60.4	58.6	60.9
April	68.1	67.3	68.5	68.0	69.6	70.0	72.4	66.9	69.5	69.3	70.7	69.0	70.7	69.2
May	72.4	72.2	73.2	72.5	72.8	72.3	74.7	73.8	74.5	74.3	73.5	71.9	74.9	73.3
June	76.1	76.2	76.5	76.3	76.5	75.2	75.6	75.5	75.9	74.8	76.8	78.1	76.2	76.1
July	76.9	76.6	76.8	76.5	76.7	76.8	76.4	76.5	75.8	76.9	77.4	76.7	77.0	76·7
August	—	76.4	76.1	77.3	76.7	76.6	76.9	76.0	76.5	76.8	76.8	76.6	77.8	76.7
September	76.0	76.2	76.2	74.4	76.3	75.6	76.4	75.3	75.3	75.6	75.9	75.5	75.8	75.7
October	69.0	72.7	72.5	71.7	72.9	70.6	69.1	72.2	71.2	68.4	72.7	70.9	70.7	71.1
November	62.6	58.5	60.1	61.2	61.8	59.4	56.6	63.0	61.8	57.0	59.6	56.7	58.5	59.8
December	49.6	44.6	50.0	52.8	49.4	53.1	51.2	48.7	50.2	50.3	52.1	50.1	51.8	50.3
Average	65.1	65.2	65.9	65.7	66.1	66.2	65.6	65.2	65.6	65.1	66.3	65.3	65.7	65.6

Dash (—) means not available.

Source: [17].

TABLE B-8

MEAN MAXIMUM TEMPERATURE: (Srimangal Station)

Month \ Year	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	Average 1948-1960
	(...in degrees Fahrenheit...)													
January	78.1	78.5	79.1	78.1	79.2	76.9	76.5	77.6	78.5	76.7	80.4	77.4	80.0	78.2
February	79.7	82.0	80.1	84.2	85.4	84.2	85.1	83.0	83.1	79.2	80.5	80.1	87.8	82.6
March	88.1	90.3	87.7	90.5	86.8	87.8	91.1	90.6	88.9	88.6	91.6	89.3	87.7	89.2
April	89.8	85.0	92.2	90.2	91.9	93.2	92.6	91.6	92.5	96.3	93.4	92.2	98.5	92.3
May	89.2	87.2	92.1	90.6	90.5	89.7	92.1	91.1	88.6	92.7	91.5	91.0	96.2	91.0
June	89.8	88.8	88.8	89.3	89.8	88.0	87.5	89.2	85.8	89.4	92.3	89.7	90.7	89.2
July	89.1	89.2	89.4	89.0	89.0	91.7	89.3	87.9	88.3	89.9	91.5	90.5	88.0	89.4
August	—	89.0	86.6	89.9	89.7	90.6	88.7	87.3	88.5	90.7	89.2	89.9	91.8	89.3
September	89.7	89.2	90.2	89.7	88.9	89.1	90.9	89.0	88.2	89.6	91.0	88.0	89.4	89.5
October	86.9	87.8	87.7	87.2	88.0	87.4	86.4	89.4	89.1	88.0	88.8	88.7	89.0	87.8
November	82.8	84.1	83.0	84.0	82.9	83.8	83.3	84.2	84.0	85.2	85.6	84.0	83.9	83.9
December	78.3	77.0	78.8	80.9	78.9	81.1	79.6	78.1	79.5	80.5	80.1	80.7	80.8	79.6
Average	85.6	85.7	86.3	87.0	86.8	87.0	86.9	86.6	86.3	87.2	88.0	86.5	88.6	86.8

Dash (—) means not available.

Source: [17].

TABLE B-9

POPULATION OF PAKISTAN

Year (1)	East Pakistan (2)	West Pakistan (3)	Pakistan (4)
	(....................	*in millions*	....................)
1949/50	44.0	35.0	79.0
1950/51	44.9	35.9	80.8
1951/52	45.8	36.8	82.6
1952/53	46.8	37.8	84.6
1953/54	47.8	38.7	86.5
1954/55	48.8	39.7	88.5
1955/56	49.8	40.7	90.5
1956/57	50.8	41.8	92.6
1957/58	51.8	42.8	94.6
1958/59	52.9	43.9	96.8
1959/60	54.0	45.0	99.0
1960/61	55.4	46.2	101.6
1961/62	56.9	47.4	104.3
1962/63	58.4	48.7	107.1
1963/64	59.9	50.0	109.9
1964/65	61.5	51.4	112.9
1969/70	70.3	58.7	129.0

Source notes: The figures for 1949/50, 1959/60, and 1963/64 are derived from Planning-Commission data [28, p. 11, Table 12]. The implicit annual compound growth rates are as follows:

for 1949/50 to 1959/60: East Pakistan —2.07 per cent,
West Pakistan —2.55 per cent,
all Pakistan —2.28 per cent;

for 1959/60 to 1963/64: East Pakistan —2.63 per cent,
West Pakistan —2.67 per cent,
all Pakistan —2.65 per cent.

Using these growth rates, the population figures for the intermediate years have been calculated. The 1964/65 and 1969/70 figures are based on a future growth rate of 2.7 per cent for both wings.