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PRODUCTION PERFORMANCE OF BANGLADESH AGRICULTURE, 1967-70 TO 1976-79: AN ANALYSIS BY COMPONENT ELEMENTS OF GROWTH

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ABSTRACT

This paper examines the production performances of 15 major crops in Bangladesh during the period 1967-70 to 1976-79 using official data. It identifies the component elements of growth and measures their relative contributions to the growth in crop output. Three broad components of growth-area, productivity and their interaction are considered. The area component is analysed in terms of net area (rather than in gross area) and cropping pattern shifts and their interaction effects. This paper identifies ‘crop-push’ and 'area-push' shifts in cropping pattern, and the crop-push shift is analysed in terms of ‘substitution’ and ‘expansion’ effects. The yield element of the productivity component is further decomposed into ‘technology-spread’ and 'technology-neutral' yields and their interaction effects. The study reveals that the growth in total crop output at the national as well as divisional levels has been unsatisfactory over the period of study. A wide variation in the relative contributions of various component elements to the output growth of individual crops is also observed. Finally, some recommendations are made so that a better production performance of Bangladesh agriculture can be achieved.

I. INTRODUCTION

This paper is not concerned with the growth trend of agricultural output *per se;* rather it examines the production performance of crops in Bangladesh during the period 1967-70 to 1976-79. It also identifies the component elements of growth, and measures their relative contributions to the growth in crop output. Knowledge about the growth of crop output over time and the relative importance of the underlying factors responsible for such growth is crucial for better understanding of the overall agricultural production possibilities.

The component analysis of the growth in crop output has occupied an important place in agricultural economics literature, particularly in India. The increase in agricultural

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production has traditionally been explained in terms of the area and yield components. However, Minhas and Vaidyanathan (1965) added a third component, the cropping pattern. They demonstrated an 'additive scheme of decomposition' to measure the relative contributions of area, yield and cropping pattern components and an interaction component of cropping pattern and yield to the growth in agricultural output in India. The pioneering work of Minhas and Vaidyanathan attracted many researchers (Venkataramanan and Prahladachar 1980 ; Sondi and Singh 1975 ; Misra 1971) to study the relative contributions of different sources to the growth in agricultural output at the State or all-India level. In Bangladesh, following Minhas and Vaidyanathan's approach, Hossain (1980) estimated the relative contributions of various component elements to the growth in cereal production for the period 1964-67 to 1976-78. Sagar (1977) and Narain (1977) introduced respectively the price structure and locational shift components in their analyses of the growth in agricultural productivity, and made significant improvements over the Minhas-Vaidyanathan scheme.[1]

On the question of decomposition of growth into its components, the present study differs from earlier studies in three respects. Firstly, the area component is analysed in net rather than in gross terms. Secondly, the cropping pattern shift effect is explained with respect to its component effects rather than in terms of a single effect. Thirdly, the present study introduces the technological aspect in the yield element of productivity growth, and incorporates the locational shift element similar to Narain's study.

On the question of measuring the 'aggregate effect' of the shift in cropping pattern, the present study differs from Venkataramanan-Prahladachar's study in two respects. Firstly, it identifies 'crop-push' and 'area-push' shifts in cropping pattern, and then it analyses the crop-push shift in terms of 'substitution' and 'expansion' effects ; while the Venkataramanan-Prahladachar's study analyses the 'aggregate effect' of the shift in cropping pattern in terms of 'substitution' and 'expansion' effects. Secondly, the present study employed a decomposition method ; while Venkataramanan and Prahladachar (1980) suggested a method "by comparing the area growth rates in individual crops with the growth rate that occurred in the gross cropped area" (p. 81). The advantage of the present method is that it measures the substitution, expansion and area-push effects of the cropping pattern shift for each individual crop separately.

The next section presents the methodology of decomposition. The sources and limitations of data are discussed in section III. Section IV summarizes findings of the study. Policy implications are given in the concluding section.

II. METHODOLOGY OF DECOMPOSITION

The total change in the value of gross agricultural output in constant prices between two time periods may be expressed in the form of the equation :

$$0^1 - 0^0 = G^1Y^1 - G^0Y^0 \tag{1}$$

where,

0 = value of gross physical output in constant prices ;
G = gross cropped area ; Y = level of productivity in value terms at constant prices ;
and subscripts 1 = current period and 0 = base period.

The right hand side of equation 1 can be decomposed as

$$(G^1 - G^0)Y^0 + G^0(Y^1 - Y^0) + (G^1 - G^0)(Y^1 - Y^0) \tag{2}$$

Since by definition

$$G^t = \sum_r \sum_c A^t_{cr} \; ; \; Y^t = 0^t/G^t \; ; \; 0^t = \sum_r \sum_c Q^t_{cr} p_c \; ; \text{ and } y^t_{cr} = Q^t_{cr}/A^t_{cr}$$

where,

A = area ; Q = physical output ; P = constant price ; y = yield rate ; and subscripts c = c-th crop ; r = r-th division and t = t-th time period.

We can restate equation 2 as

$$\sum_r \sum_c (A^1_{cr} - A^0_{cr}) y^0_{cr} p_c + \sum_r \sum_c A^0_{cr}(y^1_{cr} - y^0_{cr}) p_c$$

$$+ \sum_r \sum_c (A^1_{cr} - A^0_{cr})(y^1_{cr} - y^0_{cr}) p_c \tag{3}$$

where,

$\sum_r \sum_c (A^1_{cr} - A^0_{cr}) y^0_{cr} p_c = (G^1 - G^0) Y^0 =$ 'pure area effect' : it measures the contribution of the change in area to the growth in crop output, keeping productivity unchanged over time ;

$\sum_r \sum_c A^0_{cr}(y^1_{cr} - y^0_{cr}) p_c = G^0(Y^1 - Y^0) =$ 'pure productivity effect' : it measures the contribution of the change in productivity to the growth in crop output, keeping area unchanged over time ; and

$\sum_{r}\sum_{c}(A^1_{cr}-A^0_{cr})(y^1_{cr}-y^0_{cr})\bar{p}_c=(G^1-G^0)(Y^1-Y^0)=$ 'area and productivity interaction effect' : it measures the contribution of the simultaneous movement in area and productivity to the growth in crop output over time.

The sources of the growth in area under individual crops may fall under two broad categories :

i. The change in area under individual crops may come about because the net cropped area[2] may have changed over time. We denote the influence of such a change in area as 'net area shift effect' .

ii. The change in area under individual crops may come about because the cropping pattern may be shifted over time. We broadly classify the effects of changes in cropping pattern as 'crop-push' and 'area-push' shift effects. We define crop-push shift effect as resulting from the changes in crop combinations over time ; while the area-push shift effect is the residual effect arising from the change in net cropped area and the resultant changes in crop combinations over time. The crop-push shift in cropping pattern creates 'substitution' and 'expansion' effects on the areas of individual crops. The substitution effect implies that the relative increase in the areas of some crops will exactly be compensated by the equivalent decrease in the areas of some other crops ; while the expansion effect brings relatively greater increase in the areas of some crops corresponding to the decline in the areas of other crops. And therefore, the gross cropped area remains unchanged owing to the substitution effect; while it increases owing to the expansion effect of a change in crop combinations. A change in the net cropped area, on the other hand, brings proportionately greater or equal or smaller change in the gross cropped area depending upon the changes in crop combinations.

By definitions, we have

$$A^t_{cr}=G^t g^t_{cr} \text{ ; and } I^t=G^t/N^t,$$

and therefore, we also have (3)

$$\sum_{r}\sum_{c} A^t_{cr}=N^t I^t \sum_{r}\sum_{c} g^t_{cr} \qquad (4)$$

where,

N=net cropped area ; I = cropping intensity (G/N) ; and g_{cr} = area under c-th crop in r-th division as the proportion of the gross cropped area (G).[3]

Following the identity equation 4, the 'pure area effect' in equation 3 can be rewritten as

$$\sum_r\sum_c(A^1_{cr}-A^0_{cr})y^0_{cr}p_c = N^1I^1\sum_r\sum_c g^1_{cr}y^0_{cr}p_c - N^0I^0\sum_r\sum_c g^0_{cr}y^0_{cr}p_c \tag{5}$$

and the right hand side of equation 5 can be decomposed as

$$\begin{aligned}&(N^1-N^0)I^0\sum_r\sum_c g^0_{cr}y^0_{cr}p_c + N^0I^0\sum_r\sum_c(g^1_{cr}-g^0_{cr})y^0_{cr}p_c\\&+N^0(I^1-I^0)\sum_r\sum_c g^0_{cr}y^0_{cr}p_c + N^0(I^1-I^0)\sum_r\sum_c(g^1_{cr}-g^0_{cr})y^0_{cr}p_c\\&+(N^1-N^0)I^0\sum_r\sum_c(g^1_{cr}-g^0_{cr})y^0_{cr}p_c + (N^1-N^0)(I^1-I^0)\sum_r\sum_c g^0_{cr}y^0_{cr}p_c\\&+(N^1-N^0)(I^1-I^0)\sum_r\sum_c(g^1_{cr}-g^0_{cr})y^0_{cr}p_c\end{aligned} \tag{6}$$

where,

$(N^1-N^0)I^0\sum_r\sum_c g^0_{cr}y^0_{cr}p_c$ = 'pure net area shift effect' : it measures the growth in crop output that would have occurred due to the change in the physical area of land, keeping cropping pattern and productivity unchanged over time ;

$N^0I^0\sum_r\sum_c(g^1_{cr}-g^0_{cr})y^0_{cr}p_c$ = 'pure substitution effect' of crop-push shift in cropping pattern : it measures the growth in crop output that would have occurred due to the changes in crop combinations in absence of a shift in the gross cropped area, keeping productivity unchanged over time ;

$N^0(I^1-I^0)\sum_r\sum_c g^0_{cr}y^0_{cr}p_c + N^0(I^1-I^0)\sum_r\sum_c(g^1_{cr}-g^0_{cr})y^0_{cr}p_c$ = 'pure expansion effect' of crop-push shift in cropping pattern : it measures the growth in crop output that would have occurred due to the changes in crop combinations in the presence of a shift in the gross cropped area, keeping productivity unchanged over time. The first term reflects the gain in area under individual crops that would have occurred due to the expansion in the gross cropped area in the absence of a shift in their own cropping pattern ; while the second term indicates the gain or loss in area under individual crops that would have occurred due to the expansion in the gross cropped area in the presence of a shift in their own cropping pattern ;

$$(N^1-N^0)I^0\sum_r\sum_c(g^1_{cr}-g^0_{cr})\,y^0_{cr}P_c+(N^1-N^0)(I^1-I^0)\sum_r\sum_c g^0_{cr}\,y^0_{cr}p_c=$$ 'pure area-push cropping pattern shift effect' : it measures the growth in crop output that would have occurred due to the residual effect arising from the change in net cropped area and the resultant crop substitutions (first term) and from the change in net cropped area and the resultant shift in the gross cropped area, i.e., the resultant crop expansion (second term), keeping productivity unchanged over time[4] ;

$$(N^1-N^0)(I^1-I^0)\sum_r\sum_c(g^1_{cr}-g^0_{cr})\,y^0_{cr}p_c=$$ 'net area and cropping pattern shift interaction effect' : it measures the growth in crop output that would have occurred due to the simultaneous shifts in net cropped area and 'aggregate' cropping pattern (i.e., due to the simultaneous effects from net area shift and crop-push and area-push shifts in cropping pattern), keeping productivity unchanged over time.

The locational shifts and changes in yield rates are viewed as two major factors responsible for a change in agricultural productivity. In a situation of static yield rates at two points of time, a region's soil characteristics together with other natural factor endowments set the broad limit within which a region may gain a comparative yield advantage over other regions. A shift in crop location from a region having a low yield to another region having a high yield and/or from a high to a low crop damaging region will enhance crop output, although a static yield rate has prevailed over the entire period in each region. We denote the influence of such changes in productivity as 'pure locational shift effect'.

The growth in productivity may also occur due to the increase in the yield rates of the region (i.e., 'pure yield effect'), keeping all other things constant. At a given level of technology[5] adoption in terms of area, the increase in the yield rates of the regions (i.e., 'pure technology-neutral yield effect') may come about because of the factors like improvement in farmers' ability with respect to input uses. Assuming input uses and other factors to be constant, the increase in the regions' yield rates, on the other hand, may come about because the level of technology adoption in terms of area has increased over time (i.e., 'pure techology-spread yield effect'). And it may also come about from interactions between these two effects.

Since we have

$$y^t_{cr} = \sum_d a^t_{cdr} y^t_{cdr}$$

where,

$a_{cdr} = A_{cdr}/A_{cr}$ = area under c-th crop at d-th district in r-th division (A_{cdr}) as the proportion of the total area under c-th crop in r-th division (A_{cr}) ; $y_{cdr} = Q_{cdr}/A_{cdr}$ = yield rate of c-th crop at d-th discrict in r-th division ; and subscript d=agricultural district as prevailed in 1967-68 ;

we can restate the 'pure productivity effect' in equation 3 as

$$\sum_r \sum_c [A^0_{cr} \sum_d (a^1_{cdr} y^1_{cdr} p_c)] - \sum_r \sum_c [A^0_{cr} \sum_d (a^0_{cdr} y^0_{cdr} p_c)] \quad (7)$$

and the above equation can be decomposed as

$$\sum_r \sum_c [A^0_{cr} \sum_d (a^1_{cdr} - a^0_{cdr}) y^0_{cdr} p_c] + \sum_r \sum_c [A^0_{cr} \sum_d a^0_{cdr} (y^1_{cdr} - y^0_{cdr}) p_c]$$

$$+ \sum_r \sum_c [A^0_{cr} \sum_d (a^1_{cdr} - a^0_{cdr}) (y^1_{cdr} - y^0_{cdr}) p_c] \quad (8)$$

where,

$\sum_r \sum_c [A^0_{cr} \sum_d (a^1_{cdr} - a^0_{cdr}) y^0_{cdr} p_c]$ = 'pure locational shift effect' : it measures the growth in crop output that would have occurred due to the shifts in crop locations in the absence of changes in yield rates, keeping crop areas unchanged over time ;

$\sum_r \sum_c [A^0_{cr} \sum_d a^0_{cdr} (y^1_{cdr} - y^0_{cdr}) p_c]$ = 'pure yield effect' ; it measures the growth in crop output that would have occurred due to the changes in yield rates in the absence of the shifts in crop locations, keeping crop areas unchanged over time ; and

$\sum_{r}\sum_{c} [A^0_{cr} \sum_{d} (a^1_{cdr} - a^0_{cdr}) (y^1_{cdr} - y^0_{cdr}) p_c]$ = 'location and yield interaction effect' : it measures the growth in crop output that would have occurred due to the joint influence of the shift in crop location and yields, keeping crop areas unchanged over time.

Defining district yield rates of individual crops in terms of seed-based technology as

$$y^t_{cdr} = \sum_{v} a^{*t}_{cvdr} y^{*t}_{cvdr}$$

where,

$a^*_{cvdr} = A^*_{cvdr}/A_{cdr}$ = area under v-th seed variety of c-th crop at d-th district in r-th division (A^*_{cvdr}) as the proportion of the total area under c-th crop at d-th district in r-th division (A_{cdr}) ; $y^*_{cvdr} = Q^*_{cvdr}/A^*_{cvdr}$ = yield rate of v-th variety of c-th crop at d-th district in r-th division ; and subscript v = seed variety (v_1 = high-yielding variety and v_2 = local variety) and asterisk mark indicates seed-based technology ;

we can restate the 'pure yield effect' in equation 8 as

$$\sum_{r}\sum_{c}[A^0_{cr} \sum_{d} a^0_{cdr} (y^1_{cdr} - y^0_{cdr}) p_c] = \sum_{r}\sum_{c} [A^0_{cr} \sum_{d} \{a^0_{cdr} \sum_{v} (a^{*1}_{cvdr} y^{*1}_{cvdr}) p_c\}]$$

$$- \sum_{r}\sum_{c} [A^0_{cr} \sum_{d} \{a^0_{cdr} \sum_{v} (a^{*0}_{cvdr} y^{*0}_{cvdr}) p_c\}] \qquad (9)$$

The right hand side of equation 9 can be decomposed as

$$\sum_{r}\sum_{c} [A^0_{cr} \sum_{d} \{a^0_{cdr} \sum_{v} (a^{*1}_{cvdr} - a^{*0}_{cvdr}) y^{*0}_{cvdr} P_c\}]$$

$$+ \sum_{r}\sum_{c}[A^0_{cr} \sum_{d} \{a^0_{cdr} \sum_{v} a^{*0}_{cvdr} (y^{*1}_{cvdr} - y^{*0}_{cvdr}) P_c\}]$$

$$+ \sum_{r}\sum_{c} [A^0_{cr} \sum_{d} \{a^0_{cdr} \sum_{v} (a^{*1}_{cvdr} - a^{*0}_{cvdr})(y^{*1}_{cvdr} - y^{*0}_{cvdr}) P_c\}] \qquad (10)$$

where,

$$\sum_{r}\sum_{c}\Big[A^0_{cr}\sum_{d}\{a^0_{cdr}\sum_{v}(a^{*1}_{cvdr}-a^{*0}_{cvdr})y^{*0}_{cvdr}P_c\}\Big] = \text{'pure technology-spread yield effect'}$$

: it measures the growth in crop output that would have occurred due to the shift in area from local to high-yielding variety in the absence of changes in their yield rates, keeping crop locations and total areas of individual crops unchanged over time ;

$$\sum_{r}\sum_{c}\Big[A^0_{cr}\sum_{d}\{a^0_{cdr}\sum_{v} a^{*0}_{cvdr}(y^{*1}_{cvdr}-y^{*0}_{cvdr})P_c\}\Big] = \text{'pure technology-neutral yield effect'}$$

: it measures the growth in crop output that would have occurred due to the changes in the yield rates of the two varieties of individual crops in the absence of a varietal shift in area, keeping crop locations and total areas of individual crops unchanged over time; and

$$\sum_{r}\sum_{c}\Big[A^0_{cr}\sum_{d}\{a^0_{cdr}\sum_{v}(a^{*1}_{cvdr}-a^{*0}_{cvdr})(y^{*1}_{cvdr}-y^{*0}_{cvdr})P_c\}\Big] = \text{'technology-spread and}$$

technology-neutral yield interaction effect' : it measures the growth in crop output that would have occurred due to the joint influence of varietal shifts in area and yield, keeping crop locations and total areas of individual crops unchanged over time.

The complete decomposition scheme can be obtained by adding equations 6, 10, the first and third terms in equation 8, and the third term in equation 3.

III. DATA

Data utilized in the study are obtained from various publications of the Bangladesh Bureau of Statistics (BBS). To reduce the effects of the random fluctuations in the time-series data on area, output and yields, the three-year averages centred at 1968-69 and 1977-78 are used instead of the annual figures given by the Bureau. The average prices which have been used as the weights in the output estimates of different crops are the 'home-stead prices' for the years 1972-73, 1973-74 and 1974-75 as reported in *The Year Book of Agricultural Statistics of Bangladesh*, 1976-77 (BBS 1978).

The periods 1967-70 and 1976-79 are respectively taken as the base and the current period. The choice of the base period rests on two considerations. Firstly, it facilitates in obtaining the time-series data which are comparable and uniform with respect to the methods of crop estimates.[6] Secondly, a technological transformation of agriculture, commonly known as 'the green revolution', became perceptible during the late 1960's, and therefore, the base period may serve as the starting point of an era of agricultural transformation in Bangladesh. It may also serve as the basis of determining the performance of our agriculture since independence.

The present analysis covers such time-span as the availability of data permits. The non-availability of relevant data, particularly for earlier years, has made our method of decomposition more restrictive (see footnote 3). The present analysis is confined to 15 major crops. They are *aman, aus* and *boro* rice, wheat, jute, sugarcane, rape and mustard, *til* (sesamum), potato, sweet potato, *khesari* (chickling vetch), gram, *masur* (lentil), chillies and tobacco. They cover more than 93 percent of the gross cropped area. Some crops with smaller acreages are ignored in the present analysis; while some crops are omitted due to the lack of reliable statistics. There are enough reasons to believe that the official agricultural statistics are largely unreliable (Pray 1980), but because of the absence of alternative sources of data at the macro level, we have decided to accept them, *albeit* with much reservations. The quantitative results of the study should therefore be interpreted with caution.

IV. RESULTS

Production Performances of Crops

Since the late sixties, various agricultural programmes have been launched by the government to boost up crop output in Bangladesh. But, unfortunately, the overall agricultural production has failed to get accelerated. This is evident in Table 1. During the period 1967-70 to 1976-79, total crop production in Bangladesh is estimated to have increased only by 7.25 percent, that is, at an average annual rate of 0.81 percent—a rate which should be a matter of serious concern.

None of the four divisions in Bangladesh achieved higher rates of growth in crop output than their respective population growth rates during this period. Dhaka division recorded the maximum annual rate of increase in crop production (1.32 percent), followed by Khulna division (1.12 percent) and Rajshahi division (0.81 percent). Crop production in Chittagong division remained virtually unchanged during the period under study.

The period 1967-70 to 1976-79 is characterized by the wide variations in the production performances of individual crops at the national level. In Bangladesh, the most spectacular output growth (36.42 percent per annum) occurred in the case of wheat.

TABLE 1 OUTPUT GROWTH OF INDIVIDUAL CROPS IN DIFFERENT DIVISIONS OF BANGLADESH, 1967-70 TO 1976-79

(percent per annum)

Crop	Dhaka	Chittagong	Rajshahi	Khulna	Bangladesh
Aman rice	1.54	-0.41	0.76	0.74	0.61
	(21.98)	(-7.42)	(15.29)	(10.86)	(40.71)
Aus rice	1.74	0.47	0.21	1.31	0.88
	(9.75)	(2.48)	(1.50)	(6.18)	(19.90)
Boro rice	2.44	1.58	9.27	7.64	2.85
	(12.80)	(9.76)	(9.22)	(5.92)	(37.70)
Wheat	15.07	89.91	31.77	63.94	36.42
	(2.54)	(3.69)	(8.01)	(6.00)	(20.24)
Jute	-1.98	-5.59	-1.34	1.92	-1.69
	(-5.36)	(-3.55)	(-2.45)	(1.38)	(-9.99)
Sugarcane	0.24	-1.34	-1.30	-1.59	-1.34
	(0.20)	(-0.26)	(-3.85)	(-1.18)	(-5.09)
Rape and Mustard	-1.17	11.22	-0.64	-3.06	0.14
	(-0.74)	(2.37)	(-0.53)	(-0.83)	(0.27)
Til	-2.74	-6.61	2.01	5.13	-0.78
	(-0.30)	(-0.55)	(0.18)	(0.40)	(-0.28)
Potato	1.64	0.77	-0.06	-2.11	0.62
	(1.79)	(0.55)	(-0.06)	(-0.44)	(1.85)
Sweet potato	3.76	-4.22	1.87	3.08	-0.44
	(1.45)	(-2.86)	(0.29)	(0.52)	(-0.61)
Khesari	-3.27	4.32	1.72	-0.69	-0.64
	(-0.51)	(0.10)	(0.21)	(-.05)	(-0.24)
Gram	-0.22	-6.85	-1.44	-3.22	-2.18
	(-0.02)	(-0.04)	(-0.15)	(-0.61)	(-0.82)
Masur	-2.79	0.07	4.12	-3.09	-0.28
	(-0.23)	(0.00)	(0.51)	(-0.37)	(-0.09)
Chillies	-3.07	-1.33	-0.98	-4.38	-2.39
	(-1.41)	(-1.01)	(-0.49)	(-2.64)	(-5.56)
Tobacco	0.53	-3.34	2.63	24.17	3.31
	(0.04)	(-0.28)	(1.02)	(1.23)	(2.01)
All	1.32	0.09	0.81	1.12	0.81
	(42.00)	(2.97)	(28.68)	(26.35)	(100.00)

Figures in parentheses indicate percent conttributions to the output growth of all crops in Bangladesh. They may not add up to the respective total due to rounding errors.

Area under wheat constituted nearly 2 percent of the gross cropped area in recent years. But, the contribution of wheat to the growth in all crop output approximated 20 percent. A noteworthy annual increase in output came from tobacco (3.31 percent) and *boro* rice (2.85 percent); while the growth rates per annum were insignificant for rape and mustard (0.14 percent), *aman* rice (0.61 percent), potato (0.62 percent) and *aus* rice (0.88 percent). The production of the remaining crops, in fact, fell during the period. The most noticeable decrease in production occurred in the case of chillies, gram, jute and sugarcane (2.39, 2.18, 1.69 and 1.34 percent per annum, respectively).

Table 1 also shows that individual crops performed differently in different divisions during the period under study. Dhaka division achieved higher rates of growth per annum in the production of *aman* rice (1.54 percent), *aus* rice (1.74 percent), sugarcane (0.24 percent), potato (1.64 percent) and sweet potato (3.76 percent) than other divisions. Wheat (89.91 percent), rape and mustard (11.22 percent) and *khesari* (4.32 percent) performed better in Chittagong division than in other divisions. Rajshahi division recorded maximum annual growth in *boro* rice (9.27 percent) and *masur* (4.12 percent) production. The annual growth rates were higher for jute (1.92 percent), *til* (5.13 percent)and tobacco (24.17 percent) production in Khulna division than those in the remaining divisions. The average annual rates of decrease in production were prominent for *khesari* in Dhaka division, gram, *til* and jute in Chittagong division, *masur* and rape and mustard in Khulna division. But, the most adverse effect on the overall growth in total crop output in Bangladesh came from the declining production of *aman* rice in Chittagong division, followed by jute in Dhaka division and sugarcane in Rajshahi division, and their negative contributions were 7.42, 5.36 and 3.85 percent, respectively.

Component Elements of Growth

During the period 1967-70 to 1976-79, different component elements had little influence in bringing an increase in total crop output at the national as well as divisional levels. This is apparent in Table 2.

At the national level, annual average growth rates attributable to the area and productivity and their interaction effects stood at 0.09, 0.71 and 0.01 percent whose respective contributions to the growth in total crop output were 11, 88 and 1 percent.

The increase in crop output in Bangladesh due to the area component of growth came neither from an increase in the net cropped area nor from an increase in the gross cropped area (in fact they decreased over the period ; Appendix Table I) ; it came solely from crop-push shift in cropping pattern. The adverse net area shift effect brought down

TABLE 2 RELATIVE CONTRIBUTIONS OF DIFFERENT COMPONENT ELEMENTS TO THE OUTPUT GROWTH OF ALL CROPS IN DIFFERENT DIVISIONS OF BANGLADESH, 1967-70 TO 1976-79

(percent per annum)

Component element	Dhaka	Chittagong	Rajshahi	Khulna	Bangladesh
Pure Area Effect[a]	0.28	-0.48	0.25	0.41	0.09
	(8.84)	(-16.02)	(8.73)	(9.71)	(11.26)
Net area shift effect					-0.55
					(-67.95)
Cropping pattern shift effect					0.64
					(79.27)
Crop-push shift					0.67
					(83.30)
Substitution effect					0.32
					(40.17)
Expansion effect					0.35
					(43.13)
Area-push shift					-0.03
					(-4.03)
Net area & cropping pattern interaction effect					—
					(-0.06)
Pure Productivity Effect	1.10	0.63	0.50	0.61	0.71
	(35.13)	(20.93)	(17.71)	(14.41)	(88.18)
Locational shift effect	0.03	0.16	0.02	0.03	0.06
	(0.97)	(5.37)	(0.77)	(0.69)	(7.80)
Yield effect	1.04	0.37	0.46	0.57	0.61
	(33.17)	(12.19)	(16.43)	(13.46)	(75.25)
Location & yield interaction effect	0.03	0.10	0.02	0.01	0.04
	(0.99)	(3.37)	(0.51)	(0.26)	(5.13)
Area & Productivity Interaction effect	-0.06	-0.06	0.06	0.10	0.01
	(-1.97)	(-1.94)	(2.24)	(2.23)	(0.56)
All	1.32	0.09	0.81	1.12	0.81
	(42.00)	(2.97)	(28.68)	(26.35)	(100.00)

Figures in parentheses indicate percent contributions to the output growth of all crops in Bangladesh.

a. Elements of pure area component of growth could not be ascertained due to the non-availability of relevant data (see footnote 3).

crop production at an average annual rate of 0.55 percent. The crop-push shift in cropping pattern led total crop output to increase at an annual average rate of 0.67 percent and contributed 83 percent to the growth in crop output. The total effect due to the crop-push shift in cropping pattern was almost equally shared by its two components—substitution and expansion effects. The area-push shift in cropping pattern was responsible for bringing down crop output by 0.03 percent per annum. Net area and cropping pattern shift interaction effect had no impact on the growth in total crop output.

As for productivity component of growth, a major part of the output increase in Bangladesh was attributable to the yield effect. The total crop production in Bangladesh is estimated to have increased by 0.06, 0.61 and 0.04 percent per annum owing to the shifts in crop locations and yields and their interaction effects—the three major sources of productivity changes. They respectively contributed 8, 75, and 5 percent to the total output increase in Bangladesh agriculture.

At the divisional level, growth rates attributable to the different elements of area component could not be ascertained individually due to the non-availability of relevant data (see footnote 3). Owing to the various elements of area component, the maximum annual increase in crop production occurred in Khulna division (0.41 percent), followed by Dhaka (0.28 percent) and Rajshahi (0.25 percent) divisions ; while crop production in Chittagong division declined by 0.48 percent. The annual rates of increase in crop output due to the productivity changes ranged from 1.10 percent in Dhaka division to 0.50 percent in Rajshahi division. The major source of growth in productivity came from yield effects in all divisions. The locational shift and its interaction effects were more prominent in Chittagong division than those in other divisions (Table 2).

The contributions of different component elements to the output growth of individual crops in Bangladesh are presented in Table 3. During the period 1967-70 to 1976-79, the higher growth in production occurred in the cases of wheat, *boro* rice and tobacco than other crops owing to the increase in their respective areas over time. For these crops, the gain in area due to the cropping pattern shift effect was substantially greater than the loss incurred owing to the net area shift effect (Appendix II). A similar situation, with lesser intensity, also existed for *masur, khesari,* potato, sweet potato and *til.* The areas of all other crops fell over time. For *aman* and *aus* rice, the area decrease due to the negative net area shift effect was greater than the area increase owing to the positive cropping pattern shift effect (Appendix Table II). As a result, the production of *aman* and *aus* rice in Bangladesh declined by 0.27 and 0.28 percent per annum, respectively (Table 3). The areas of the remaining crops fell due to the adverse shifts in the net area as well as cropping pattern (Appendix Table II) ; and the most noticeable decrease in output occurred in the case of jute, followed by gram, sugarcane, and chillies (Table 3).

TABLE 3 RELATIVE CONTRIBUTIONS OF VARIOUS COMPONENT ELEMENTS TO THE OUTPUT GROWTH OF INDIVIDUAL CROPS IN BANGLADESH, 1967-70 TO 1976-79

(percent per annum)

Component element	*Aman* rice	*Aus* rice	*Boro* rice	Wheat	Jute
Pure Area Effect	-0.27	-0.28	3.45	11.86	-2.42
	(-44)	(-33)	(121)	(33)	(142)
Net area shift effect	-0.55	-0.54	-0.54	-0.55	-0.54
	(-90)	(-62)	(-19)	(-1)	(32)
Cropping pattern shift effect	0.28	0.26	4.00	12.43	-1.88
	(46)	(29)	(140)	(34)	(110)
Crop-push shift	0.29	0.27	4.20	13.05	-1.97
	(48)	(30)	(147)	(36)	(116)
Substitution effect	-0.04	-0.07	3.75	12.34	-2.24
	(- 7)	(- 8)	(131)	(34)	(132)
Expansion effect	0.33	0.34	0.45	0.71	0.27
	(55)	(38)	(16)	(2)	(-16)
Area-push shift	-0.01	-0.01	-0.20	-0.62	0.09
	(- 2)	(- 1)	(- 7)	(- 2)	(- 6)
Net area & cropping pattern interaction effect	—	—	-0.01	-0.02	—
	(—)	(—)	(—)	(—)	(—)
Pure Productivity Effect	0.89	1.31	-0.46	12.39	0.92
	(146)	(150)	(-16)	(34)	(-54)
Locational shift effect	0.02	—	0.43	0.42	0.02
	(3)	(—)	(15)	(1)	(-1)
Yield effect	0.83	1.35	-0.97	11.29	0.80
	(137)	(154)	(-34)	(31)	(-47)
Location & yield interaction effect	0.04	-0.04	0.08	0.68	0.10
	(6)	(-4)	(3)	(2)	(-6)
Area & Productivity Interaction Effect	-0.01	-0.15	-0.14	12.17	-0.19
	(-2)	(-17)	(-5)	(33)	(12)
All	0.61	0.88	2.85	36.42	-1.69
	(100)	(100)	(100)	(100)	(100)

Figures in parentheses indicate percent contributions to the output growth of individual crops.

TABLE 3 (CONTINUED)

(percent per annum)

Component element	Sugarcane	Rape & Mustard	*Til* *	Potato	Sweet Potato
Pure Area Effect	-1.01	-0.54	0.01	0.88	0.10
	(75)	(-384)	(- 2)	(142)	(-22)
Net area shift effect	-0.61	-0.55	-0.55	-0.55	-0.55
	(45)	(-387)	(70)	(-88)	(124)
Cropping pattern shift effect	-0.40	0.01	0.56	1.43	0.65
	(30)	(3)	(-72)	(230)	(-146)
Crop-push shift	-0.42	0.01	0.59	1.50	0.68
	(31)	(3)	(76)	(242)	(-153)
Substitution effect	-0.77	-0.32	0.25	1.13	0.33
	(57)	(-229)	(-32)	(182)	(-75)
Expansion effect	0.35	0.33	0.34	0.37	0.35
	(-26)	(232)	(-44)	(60)	(-78)
Area-push shift	0.02	—	-0.03	-0.07	-0.03
	(-1)	(—)	(4)	(-12)	(7)
Net area & cropping pattern interaction effect	—	—	—	—	—
	(—)	(—)	(—)	(—)	(—)
Pure Productivity Effect	-0.38	0.58	-1.06	-0.20	-0.64
	(28)	(408)	(137)	(32)	(145)
Locational shift effect	0.10	-0.04	0.03	-0.09	0.23
	(-8)	(-31)	(-4)	(-14)	(-52)
Yield effect	-0.57	0.39	-1.28	-0.25	-0.87
	(43)	(275)	(165)	(-41)	(197)
Location & yield interaction effect	0.09	0.23	0.19	0.14	—
	(-7)	(164)	(-24)	(23)	(—)
Area & Productivity Interaction Effect	0.05	0.10	0.27	-0.06	0.10
	(-3)	(76)	(-35)	(-10)	(-23)
All	-1.34	0.14	-0.78	0.62	-0.44
	(100)	(100)	(100)	(100)	(100)

Figures in parentheses indicate percent contributions to the output growth of individual crops.

TABLE 3 (CONTINUED)

(percent per annum)

Component element	*Khesari**	Gram	*Masur*	Chillies	Tobacco
Pure Area effect	0.95	-1.73	1.30	-0.76	2.91
	(-147)	(80)	(-468)	(32)	(88)
Net area shift effect	-0.55	-0.54	-0.55	-0.55	-0.55
	(85)	(25)	(196)	(23)	(-17)
Cropping pattern shift effect	1.50	-1.19	1.85	-0.21	3.46
	(-232)	(55)	(-665)	(9)	(105)
Crop-push shift	1.57	-1.25	1.94	-0.22	3.63
	(-244)	(58)	(-698)	(10)	(110)
Substitution effect	1.20	-1.54	1.56	-0.54	3.20
	(-186)	(71)	(-560)	(23)	(97)
Expansion effect	0.37	0.29	0.38	0.32	0.43
	(-58)	(-13)	(-138)	(-13)	(13)
Area-push shift	-0.07	0.06	-0.09	0.01	-0.17
	(12)	(-3)	(33)	(-1)	(-5)
Net area & cropping pattern interaction effect	—	—	—	—	—
	(—)	(—)	(1)	(—)	(—)
Pure Productivity Effect	-1.50	-0.53	-1.60	-1.79	-0.04
	(232)	(24)	(577)	(75)	(-1)
Locational shift effect	0.17	0.08	0.06	-0.02	0.20
	(-27)	(-4)	(-20)	(1)	(6)
Yield effect	-1.75	-0.71	-1.62	-1.73	-0.54
	(271)	(33)	(581)	(72)	(-16)
Location & yield interaction effect	0.08	0.10	-0.04	-0.04	0.30
	(-12)	(-5)	(16)	(2)	(9)
Area & Productivity Interaction Effect	-0.09	0.08	0.02	0.16	0.44
	(15)	(-4)	(-9)	(-7)	(13)
All	-0.64	-2.18	-0.28	-2.39	3.31
	(100)	(100)	(100)	(100)	(100)

Figures in parentheses indicate percent contributions to the output growth of individual crops.

Table 3 shows that the yield effect became the major source of productivity changes in the case of individual crops. The maximum growth in productivity came from wheat production, followed by *aus* rice, jute, *aman* rice and rape and mustard. Other crops, namely, *boro* rice, sugarcane, pulses, chillies had negative productivity effects.

Table 3 also indicates that the relative contributions of different component elements to the output growth varied significantly from one crop to another. For instance, the area and productivity and their interaction effects were almost equally important for the output growth in wheat production. But, the output growth in *boro* rice came mostly from the area growth ; while the productivity increase was the major contributory factor to the output growth in other rice production.

In decomposing the pure effects of yield growth, the present analysis is confined to the yields of *aus* and *boro* rice. The non-availability of relevant data for earlier years prevented the inclusion of other crops in this decomposition analysis. The results are presented in Table 4.

Table 4 suggests that the only source to the increase in the average yields of *aus* and *boro* rice in Bangladesh was due to the technology-spread yield effect (i.e., the effect of the changes in area from local to high-yielding varieties). In all divisions of Bangladesh, the yield rates of both local and high-yielding varieties of *aus* and *boro* rice declined considerably over time, and consequently, the technology-neutral yield effect was negative in all cases. Despite the variations in the intensities of these effects, a common feature that emerges from Table 4 is that with the exception of Rajshahi division, the negative technology-neutral yield and its interaction effects were smaller in the case of *aus* rice and greater in the case of *boro* rice than their respective positive technology-spread yield effects in all divisions.

V. POLICY IMPLICATIONS AND CONCLUSIONS

During the period 1967-70 to 1976-79, a spectacular growth in wheat production, together with moderate growth in *boro* rice and tobacco, failed to bring about any perceptible increase in the total crop output in Bangladesh. This is because they had low base production. Other crops showed a slow growth or a declining production. The differ-

TABLE 4 POINT CONTRIBUTIONS OF DIFFERENT YIELD ELEMENTS TO THE OUTPUT GROWTH OF *AUS* AND *BORO* RICE IN DIFFERENT DIVISIONS OF BANGLADESH, 1967-70 TO 1976-79

(percent per annum)

Element	Dhaka	Chittagong	Rajshahi	Khulna	Bangladesh
			Aus rice		
Pure tech.-spread yield effect	3.17	7.31	1.55	3.67	3.72
Pure tech.-neutral yield effect	-0.51	-1.16	-1.26	-0.82	-0.96
Tech.-spread & tech.-neutral yield interaction effect	-0.49	-3.04	-0.78	-1.62	-1.41
All	2.17	3.11	-0.49	1.23	1.35
			Boro rice		
Pure tech.-spread yield effect	3.94	3.75	5.27	2.33	3.85
Pure tech.-neutral yield effect	-3.14	-3.19	-2.68	-3.14	-3.13
Tech.-spread & tech.-neutral yield interaction effect	-1.65	-1.84	-1.51	-0.98	-1.69
All	-0.85	-1.28	1.08	-1.79	-0.97

ential production performances of individual crops leading to an unsatisfactory growth in total crop output (Table 1) demand fundamental changes in production policy and require a 'big-push' in some additional crops, especially *aman* rice which shares a significant portion of the total area and production of Bangladesh agriculture.

One of the major constraints in achieving a high rate of growth in total or individua crop output in Bangladesh was the reduction in net cropped area, which caused adverse net area shift effect (Tables 2 and 3). Since the growing demand for land for non-agricultural uses has so far been met through the reduction in the 'culturable waste land',[7] the reduction in the net cropped area came mostly from the growth in the 'current fallow land'[8] (Appendix Table I ; Hossain 1980, p. 45). The adverse net area shift effect is, therefore, likely to intensify if the present rate of growth in current fallow land is allowed to persist. Even if the policy measures of the government succeed in reducing the growth in current fallow land, one can hardly be optimistic about the future contribution of net area shift effect because of the growing demand for land caused by the growth in population and non-agricultural development needs.

One may, however, show optimism (which is rather extremely conditional) for the cropping pattern shift effect—the other area component of the output growth. The reason for such optimism lies in the fact that the growth in total crop output owing to the cropping pattern shift effect was very low compared to some parts of India, and it can be improved significantly by taking appropriate measures. For instance, total crop production at the State of Gujarat in India grew at an annual rate of 3.09 percent owing to the substitution effect of the cropping pattern shift (Minhas and Vaidyanathan 1965, p. 242)—a rate which was much higher than the rate (0.32 percent) achieved in Bangladesh. A high rate of growth due to the substitution effect is obtained when farmers reallocate their land in favour of high value crops. The policy-makers should, therefore, emphasize the need for balancing production and price policies, and provide greater incentives to the farmers to cultivate more of these crops. The extension people can also play a vital role to increase the awareness of the farmers in this direction.

The potential for achieving a high rate of growth through the expansion effect of a change in cropping pattern is also promising in Bangladesh. A success in expanding the command areas of existing irrigation projects together with the larger investment on irrigation will bring vast fallow land under cultivation during the winter season, and the resultant increase in cropping intensity will enhance growth attributable to the expansion effect. In order to intensify the expansion effect of a change in cropping pattern, one may also recommend a shift in acreage from perennial crops to seasonal crops. Such a recommendation, however, must be based on a thorough economic as well as ecological investigation.

Theoretically, the potential for productivity improvement (yield improvement, in particular) in Bangladesh is high ; yet its practical realization was inadequate in the past. The past policy prescription for yield improvement in few crops, such as, rice, wheat, jute, with little or no attention to other crops (Table 3) has failed in achieving a desirable rate of growth in total output due to the yield effect (Table 2). The efficacy of the above prescription is constrained by the greater reliance on the area expansion under the seed-based technology with little attention to the socio-economic and organizational factors including the development of appropriate supporting services like research, extension, credit, engineering, etc. (c.f., technology-spread yield and technology-neutral yield effects in Table 4). Although this is a broad question deserving a separate study, the present analysis suggests that the policy-makers should pay increasing attention to the above factors while recommending the seed-based technology strategies for better yield effects in the future.

Despite the fact that there existed wide variations in the district level average yields of different crops, little gains have so far been realized from such comparative yield advantages (see crop location shift effects in Tables 2 and 3). It indicates that the shift in crop locations—the other source of productivity improvement—has a great potentiality in Bangladesh which should be included in future production policy recommendations.

Notes :

1. A well documented review of some decomposition schemes of growth trends by Sagar (1980) is referred for further consultation.

2. Net cropped area refers to the physical boundary of land under cultivation.

3. The non-availability of data on G_r and N_r for 1967-68 and 1968-69 precluded the use of the following identity equation :

$$\sum_r \sum_c A^t_{cr} = \sum_r [N^t_r I^t_r \sum_c g^t_{cr}]$$

where,

$$A^t_{cr} = G^t_r g^t_{cr} \text{ and } I^t_r = G^t_r / N^t_r.$$

As a result, the growth in area and output owing to the different elements of area component could not be ascertained at the divisional levels. Moreover, the output growth attributable to the area component in Bangladesh was also affected due to the weights given by the divisional yield rates.

4. In a strict sense of the term, the effect should not be called a 'pure' one. This is a second order interaction effect ; while, the 'net area and cropping pattern shift interaction effect' is a third order interaction effect.

5. Throughout this paper the term 'technology' refers to the seed-based technology, and is measured by the area under high-yielding varieties.

6. For details, see BBS (1978) ; Hakim (1967). For a comparison of results from different methods see Larson (1967) ; Pray (1980).

7. 'Culturable waste land' means the land area which is fit for cultivation, but which was not cropped within at least two successive years, or which is yet to be brought under cultivation.

8. 'Current fallow land' means the land area which was not cropped throughout a year, but which was cropped in the preceding year.

APPENDIX TABLE I

LAND UTILIZATION IN BANGLADESH, 1967-70 AND 1976-79

(000 acres)

Particular	Average 1967-70	Average 1976-79
Area not available for cultivation[1]	11955	12089
Culturable waste land	866	647
Current fallow land	747	1899
Net cropped area	21712	20646
Gross cropped area	31805	31160
Cropping intensity (percent)	146.49	150.92

Source : BBS

1. The area includes forest, rivers, etc.

APPENDIX TABLE II

CHANGES IN AREA UNDER INDIVIDUAL CROPS IN BANGLADESH IN TERMS OF THE COMPONENT ELEMENTS, 1967-70 TO 1976-79

(acres)

Crop	Net area shift effect	Cropping pattern shift effect					Net area & cropping pattern interaction	Total change
		Crop-push shift			Area-push shift	Total		
		Substi-ution	Expansion	Total				
Aman rice	-718965	-23374	442823	419449	20632	398817	35	-320113
Aus rice	-398431	-28851	244919	216068	-10653	205415	43	-192973
Boro rice	-93831	629004	76940	705944	-33730	672214	-936	577447
Wheat	-12736	256642	15632	272274	-12989	259285	-382	246167
Jute	-114130	-466310	56281	-410029	19442	-390587	694	-504023
Sugarcane	-19925	-24637	11546	-13091	606	-12485	37	-32373
Rape & mustard	-26482	-24010	15610	-8400	377	-8023	36	-34469
Til	-6294	3594	3992	7586	-368	7218	-5	919
Potato	-9926	19888	6725	26613	-1278	25335	-30	15379
S. potato	-8471	8533	5484	14017	-676	13341	-13	4857
Khesari	-11054	24745	7568	32313	-1550	30763	-37	19672
Gram	-8085	-22983	4291	-18692	884	-17808	34	-25859
Masur	-8686	23733	6078	29811	1428	28383	-35	19662
Chillies	-10611	-11714	6191	-5523	254	-5269	17	-15863
Tobacco	-5524	33272	4416	37688	-1801	35887	-49	30314
Other[1]	-108700	-397532	55014	-342518	16228	-326290	591	-434399
All	-1561851	—	963510	963510	-47314	916196	—	-645655

1. These crops were not included in the present analysis.

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