MEASURING SOURCES OF CROP OUTPUT GROWTH IN BANGLADESH*

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ABSTRACT

A decomposition model has been used to measure sources of individual and aggregate crop output growth between 1967-70 and 1981-84. Growth in output has been attributed to changes in area, yield and area-yield interaction and the area effect has been further attributed to changes in net area, cropping intensity, cropping pattern and their interactions. Results show that over 50 percent of increased output has come from increased yield and about 33% from increased area. The area-effect has resulted almost entirely from increased cropping intensity. Substitution of high value crops for low value crops has made some positive contribution but that has been balanced by the effect of decrease in net crop area. In the future, productivity growth through increased irrigation and complementary input use should assume greater importance because net crop area will continue to decline and cropping intensity may soon level off.

INTRODUCTION

A number of studies have shown that although the rate of growth of food-grain production in Bangladesh has improved in recent years, both short and long-term rates of growth remained well below the rate of population growth (see, for example, Ahmed, 1977; Clay and Khan, 1983; Hossain, 1980; Hamid, 1980; Nelson, 1983; Murshed, 1983; World Bank, 1983; Hossain, 1984; Wennergren et al., 1984; Murshed et al., 1984; Barker and Herdt, 1985). Few studies which analyzed the crop sector as a whole, have found that the sector level performance was poorer than that of foodgrain production (see, Pray, 1979; Hossain, 1980; Murshed, 1983; Murshed et al., 1984).

In order to understand the causes of poor performance, these authors have tried to trace the sources of increased production. Some authors have used Venegas and Ruttan's (1984) decomposition technique and attributed increased output to changes in area, yield and area-yield interaction (see, Ahmed, 1977; Clay and Khan, 1977; Hossain, 1980; Hamid, 1980; Nelson, 1983; World Bank, 1983; Barker and Herdt, 1985). Some others have used Minhas and Vaidyanathan's (1965) model whereby area, yield, cropping pattern and 'yield-cropping pattern interaction' have been identified as sources of output growth (see, Pray, 1979; Hossain, 1980; Wennergren et al., 1984). Murshed (1983) and Murshed et al. (1984) modified Minhas-Vaidyanathan's model and attributed output growth to changes in area, yield and area-yield interaction, then the area effect has been further attributed to changes in net area, cropping intensity, cropping pattern and their interactions.

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Apart from the elements (sources of growth) included in the various decomposition models, these studies also differ in respect of time period covered, sets of prices (base vs current year) used for valuation of output, the level of aggregation used in classifying crops. Consequently, the results are not easily comparable. However, the methodology of Murshed et al. (1984) appear to be more appropriate in the Bangladesh context where, in recent years, net cropped area has declined, cropping intensity has increased and cropping pattern has changed due to flood control and irrigation development programmes, and this model can capture the effects of these changes along with any effect of increased yield.

The objective of this paper is to use a slightly revised version of the model developed by Murshed et al. (1984) in order to understand past sources of output growth and their implications for the future. This is considered important because net area has further declined due to the process of urbanization; intensity of cropping has nearly leveled off and is expected to grow slowly. Between 1967-70 and 1981-84, net cropped area decreased from 21.69 million acres to 21.28 million acres and cropping intensity increased from 147% to 154% (BBS 1986). During the late 1960s, winter irrigation contributed both to increased yield and cropping intensity because high yielding varieties of paddy were produced on land which previously remained un-or under-utilized during the winter season. By the middle of the 1970s, irrigated crops started replacing traditional winter crops such as pulses and oilseeds, so the net effect of irrigation expansion from that time became more prominent on yield increase and marginal on cropping intensity. This trend is likely to continue in the future particularly because irrigation and flood control programmes are expensive and time consuming to implement. Therefore the potential sources of output growth need to be continuously reassessed.

The model and the data are described in section 2, the results are described in section 3 with conclusions at the end.

Methodology and Data

Change in the value of output of any crop at constant price between two periods may be expressed as:

$$O_c\ O_b = A_c\ Y_c P - A_b Y_b P \qquad (1)$$

Where 0 = value of output, A= area in acres, Y=yield per acre, P= constant price per unit of output, c=current period, b= base period. The right hand side of equation (1) may be rewritten by collecting terms as:

$$(A_c - A_b)\ Y_b P + (Y_c - Y_b)\ A_b P + (A_c - A_b)\ (Y_c - Y_b) P \qquad (2)$$

where the first term measures the contribution of change in area to growth when yield and price are held unchanged; the second term measures the contribution of change in yield to growth when area and price remain unchanged; the third term measures the contribution of simultaneous change (which may or may not be in the same direction) in area and yield. Since total change in output is given, the area-yield interaction effect may be viewed as the residual effect.

Now, the area under a crop $_j$ (A_j) may be expressed as:

$$A_j = N.\ \Sigma_j A/N.\ A_j/\Sigma_j A = N.I.G. \qquad (3)$$

Where N= net cropped area, I= cropping intensity, G= share of crop j in gross cropped area which indicates cropping pattern. Substituting equation (3) in the first term of equation (2) and collecting terms we may write[1]:

$$(N_cI_cG_c - N_bI_bG_b)Y_bP = (N_c\text{-}N_b)\ I_bG_bY_bP + (I_c\text{-}I_b)\ N_bG_bY_bP + (G_c\text{-}G_b)\ N_bI_bY_bP + (N_c\text{-}N_b)\ (I_c\text{-}I_b)\ (G_c\text{-}G_b)\ Y_bP \qquad (4)$$

where the first term measures the effect of change in net crop area when cropping intensity, cropping pattern, yield and price remain unchanged; the second term measures the effect of change in cropping intensity when net area, cropping pattern, yield and price remain unchanged; the third term measures the effect of change in cropping pattern when net area, cropping intensity, yield and price remain unchanged; and the fourth term measures the effect of simultaneous change in net area, cropping intensity and cropping pattern when yield and price remain unchanged.

Thus, total change in output may be attributed to changes in area, yield, and area-yield interaction (equation 2) and that the area effect may be further attributed to changes in net area, cropping intensity, cropping pattern and their interactions (equation 4). These two equations were applied to measure growth in crop output and their sources taking the averages of 1967-70 and 1981-84 as base and current periods respectively. These were relatively normal years yet three year averages were taken to minimize year to year fluctuations. The base period represent a time when use of seed-fertilizer-water technology took off in Bangladesh. The other reason for choosing these as base years is that available data for years before 1967 were less reliable and would need standardization using subjective judgment (see, Pray, 1980). Major floods damaged crops in 1984/85 and 1987/88 seasons, so 1983/84 was taken as the terminal year of the current period.

The necessary data were derived from various publications of the Bangladesh Bureau of Statistics and the Directorate of Agricultural Marketing. Average base year prices have been used for valuation of output. Growth rates have been calculated for 20 field crops and their aggregates to represent the crop sector. These crops represented 94.51 percent of gross cropped area in the country in the terminal year. The remaining minor crops were not included because of lack of accurate data. High and low yielding varieties of a crop were not treated as separate crops. The effect of high yielding component of a crop is reflected in higher average yield of the relevant crop.

Results and Discussion

During 1967/70-1981/84, overall crop production increased by only 1.27% per year as against the population growth rate of over 2.6% (Table 1). Actually, the production of rice, wheat, potato and tobacco have increased while production of all other crops have declined. Although the high negative growth rates of many crops have held

[1] Substitution of equation 3 in the third term of equation 2 is unnecessary because the term is multiplicative, so its final value will remain unaffected.

down the overall growth rate, their effects were marginal because those crops are of minor importance in the sector in terms of area and output.

Table 1: Annual Growth Rates of Crop Output and Their Sources, 1967/70-1981/84

Crop	Annual Growth Rate (%)	% Share of Growth by Source			
		Area	Yield	Interaction	Total
Rice[a]	1.3	40.34	54.88	4.78	100
Aus	0.51	-89.65	200.90	-11.25	100
Aman	0.69	19.94	78.94	1.12	100
Boro	4.73	72.91	17.76	9.33	100
Wheat	19.70	42.75	14.37	42.88	100
Jute	-1.93	-145.18	66.71	-19.53	100
Sugarcane	-0.95	-69.05	-33.33	2.38	100
Rape & Mustard	-0.36	-216.67	129.17	-12.50	100
Sesame	-2.46	-70.83	-35.42	6.25	100
Potato	2.01	90.33	7.99	1.68	100
Sweet Potato	-0.84	-13.85	-87.69	1.54	100
Pulses[b]	-2.17	-38.12	-68.81	6.93	100
Chillies	-2.68	-43.12	-64.83	7.95	100
Onions	-3.32	-14.39	-89.92	4.32	100
Garlic	-2.51	-45.57	-62.03	7.59	100
Tobacco	1.17	76.33	22.00	1.67	100
All Crops	1.27	33.11	51.63	15.26	100

[a] There are three annual rice crops. Aus - sown in March-April and harvested in June-July, Aman - transplanted in June-August and harvested in November-January, and Boro - transplanted in January-March and harvested in may-June.

[b] Includes lathuras, lentils, gram, moong and mashkalai.

Rice alone accounts for nearly 80% of the crop area. Among the three annual rice crops, Aman is the largest and Boro is the smallest in terms of area and output but Boro rice has made twice as much contribution to increased total crop output as compared to Aman. This has happened because irrigated high yielding rice production expanded primarily in the Boro season and Aman HYVs have been adopted only recently. The rate of growth for wheat appears to be high because it started from a low base. During the period under study, wheat has made nearly as much contribution to increased overall crop production as Aman rice.

The relative contribution of area, yield and area-yield interaction to the growth rates of individual crops and the crop sector have been measured (Table 1). It appears that over one-half of the total increase in crop output has resulted from increased yield; about one third has come from increased crop area and about 15% from area-yield interaction. The sources of growth of individual crops show wide variation. Area under Aus rice decreased substantially but yield has increased more than proportionately resulting in net increase in output. Increased area contributed nearly four-fifths of increased Boro output while increased yield contributed about four-fifths of increased Aman output. This is probably an indication that the yield increasing effect of HYV adoption in Boro season has now leveled off while this phenomena is now underway in the Aman season. Aman being a relatively large crop, its contribution to total output through increased yield remains to be tapped. Although yields of rice have increased moderately, the levels still remain low compared to other rice growing nations.

Area and area-yield interaction are of equal importance as sources of wheat output growth because, during the period under study, there has been a rapid increase in wheat acreage from a low base along with a significant shift from low to high yielding varieties. This process is now almost complete, so increased yield rate should assume greater importance in any future increase in wheat output.

In the case of jute and mustard, the effects of small increase in yields have been negated by comparatively larger effects of decrease in area. In the case of potato and tobacco, area expansion has been the main source of increased production. For all other crops, both area and yields have declined, resulting in decreased production.

Results of further decomposition of the area effect using equation 4 are shown in Table 2. During the period under consideration, net area under cultivation decreased but cropping intensity has increased and cropping pattern has changed whereby some high yield/value crops such as high yielding rice, wheat and potato, have been substituted for low yield/value crops such as pulses, oilseeds. The negative effect of decrease in net area has been of the same order as the positive effect of change in the cropping pattern. So the net positive area-effect has resulted from increased cropping intensity.

Table 2: Decomposition of the Area-Effect of Crop Output Growth, 1967/70-1981/84

Crop	Share of Total Area-Effect by source (%)				
	Net Area	Cropping Frequency	Cropping Pattern	Interaction	Total Area Effect[a]
Rice[a]	-36.27	60.4	17.9	-1.8	40.3
Aus	-42.9	71.4	-116.1	-2.1	-89.7
Aman	-41.5	69.2	-5.7	-2.0	19.9
Boro	-5.8	9.7	69.3	-0.3	72.9
Wheat	-1.5	2.6	41.8	-0.1	42.8
Jute	-9.6	16.0	-153.1	-0.4	- 147.2
Sugarcane	-24.0	40.1	-83.9	-1.2	-69.1
Rape & Mustard	-55.9	93.2	-251.3	-2.8	-216.7
Sesame	-9.1	15.2	-76.4	-0.4	-70.8
Potato	-13.4	22.2	82.1	-0.6	90.3
Sweet Potato	-28.5	47.5	-31.5	-1.4	13.9
Pulses[b]	-13.3	22.1	-46.3	-0.6	-38.1
Chillies	-8.8	14.7	-48.6	-0.4	-43.1
Onions	-8.0	13.3	-19.3	-0.4	-14.4
Garlic	-9.3	15.4	-51.3	-0.5	-45.6
Tobacco	-22.1	36.9	62.7	-1.1	76.3
All Crops	-18.2	32.7	19.8	-1.2	33.1

[a] See the area-effect in Table 1.

Taking individual crops, the positive area effects of Boro rice, wheat, potato and tobacco have resulted from increased cropping intensity and from cropping pattern changes involving substitution of other crops such as pulses and oilseeds. In terms of area, Boro rice and wheat have gained substantially from substitution because expansion of irrigation facilities in the winter season has made these two crops more profitable compared to pulses, oilseeds and other traditional crops. The positive area effect of Aman rice has come mostly from increased cropping intensity because in recent years flood control has made it possible to transplant Aman in areas which otherwise would remain fallow in the rainy season. In case of all other crops, the area effects are negative because increased cropping intensity has not been enough to compensate the adverse effects of net area decline and to change in cropping pattern.

Summary and Conclusions

An additive decomposition model has been used to measure the sources of individual and aggregate crop output growth in Bangladesh during 1967/70 – 1981/84. During the period, overall crop production increased by only 1.27% per year as against population growth of over 2.6%. Only production of rice, wheat, potato and tobacco have increased due to increase in area and yield; production of all other crops have declined due to decrease in area and/or yield. Over one half of the increased total output has come from increased yield and about one third from increased area. Further decomposition of the area effect shows that nearly the entire area-effect has resulted from increased cropping intensity in the face of decreasing net crop area. Substitution of high yield/value crops for low yield/value crops has also made some positive contribution.

These findings indicate that without further substantial yield increases, the national objective of achieving food-grain self-sufficiency may become self-defeating because on the one hand, this objective may remain unfulfilled, on the other hand, limited success in food-grain production may be achieved at the expense of making the country deficient in the production of nearly all minor but essential crops. Cropping intensity has already reached a level from where further increase will be very slow because irrigation and flood control programmes are expensive and time consuming to implement. Net crop area will also continue to decline because of urbanization, construction of various infrastructures and housing for the rapidly increasing population. So, greater attention should be given on increasing yield of not only rice and wheat but also of other crops which received inadequate attention in the past in terms of research, extension and investment in material inputs. At present only about 14% of gross cropped area or 22% of cultivated area is irrigated yet a substantial proportion of installed irrigation capacity remains underutilized; fertilizer application is about 18 kg (nutrient) per acre. So the potential for raising yield through better utilization of existing irrigation capacities, new investment in irrigation and complementary inputs seems to be quite substantial.

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