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MAGNITUDE AND SOURCES OF PRODUCTION VARIABILITY OF MAJOR FOODGRAINS IN BANGLADESH DURING THE PERIOD FROM 1979/80 TO 1998/99

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ABSTRACT

Based on national level data from secondary sources, changes in production variability and their sources of changes for Bangladesh as a whole were measured for major foodgrains- Aus, Aman and Boro rice as well as wheat during 1979/80 to 1998/99 which were again sub-divided between two time periods before full-implementation of privatization policies (1979/80-1988/89) and after full-implementation of privatization policies (1989/90-1998/99). The results showed that during the period after full-implementation of privatization policies (AFIPP) both the absolute variability (Standard Deviation, SD) and relative variability (coefficient of variation, CV) ipcreased in the cases of Aus rice, Arran rice and wheat production. Absolute variability increased but relative variability decreased in the cases of Boro rice and total foodgrains production. The increase in CV of Aman rice and wheat production is due to increase in both SD and average production of Aman rice and wheat. The increase in relative variability of Aus rice is due to increase in absolute variability and decrease in average production of Aus rice. The decrease in CV of Boro rice and total foodgrains production is attributed to increase in both SD and average production of Boro rice and total goodgrains. The results also showed that in the cases of Aus and Boro rice change in mean area: in the cases of Aman rice and total foodgrains change in mean area variance, and in the case of wheat change in yield variance contributed largely to change in production variance. Inter-regional covariance is the largest contributor to change in production variance of Aus rice, Boro rice, wheat and total foodgrains between the period before and after full implementation of privatization policies. In the case of Aman rice, Rangpur region is the largest contributor to change in production variance.

1. INTRODUCTION

Bangladesh is a food deficit country over a long period of time due to population pressure and declining per capita land availability. So, to attain foodgrain self-sufficiency the government of Bangladesh gave special emphasis to increase production through expansion of HYV seed-fertilizer irrigation technology after 1960's. An increase in the rate of diffusion of modern technology has been seen to influence area, production and yield growth of foodgrain crops. In 1979/80, total foodgrain production in Bangladesh was 13.35 million metric tons of which 12.54 million metric tons were rice and .81 million metric ton was wheat (BBS. 1985), and it rose to 24.90 million metric tons in 1999/2000 of which 23.06 million metric tons were

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rice and 1.84 million metric tons were wheat (MOF, 2000). Although seed-fertilizer-irrigation technology is an important vehicle for increasing area, yield and production growth, there is also a significant impact of privatization policies related to modern technology to change in production variability. Private investment in irrigation and deregulation of agricultural inputs during 1980s abruptly improved the diffusion of new technologies (Akteruzzman and Jaim, 1997). Liberalization of the irrigation equipment market was the dominant feature of the reform that made a substantial impact on production (Ahmed, 1995). The process of privatization and market liberalization started from early eighties and ended at the beginning of nineties. Therefore, full effects of privatization and market liberalization started from early nineties. Although foodgrain production increased substantially during the last two decades, it is important to see the variability in foodgrain production between the period before and after full-implementation of privatization and deregulation policies.

Although lots of studies have been conducted on growth of area and production of foodgrains, study related to stability of major foodgrain production at national and regional level is too limited. Privatization policy with respect to HYV seed-fertilizer-irrigation has contributed much in increasing foodgrain production in recent year, but foodgrain production fluctuates widely due to various factors. It is difficult to identify and even more difficult to quantify the causes of fluctuations in foodgrain production. Mehra (1981) observed that instability in Indian total foodgrain production has increased due to widespread adoption of the improved seed-fertilizer-irrigation technology since the mid 1960's. Hazell (1982) also argues that variance or instability in total cereal production for all India increased due to rapid adoption of modern technology since mid 1960's. Similar arguments are also put forward by Hazel] (1982), Murshid (1986), Allauddin and Tisdel (1988), Deb et al. (1991) and by Singh (1993). Singh and Ranjan (1998) examined growth and instability of principal foodgrains in West Bengal. The results showed that foodgrain production was more instable in 1980's (later period of Green Revolution) than 1970's (early period of Green Revolution). Deb et al (1991) estimated impact of new technology on production variability in Bangladesh agriculture. He concluded that in modern technology period (i) both the absolute and relative variability decreased in the cases of Aus, Aman and sugarcane, (ii) both the absolute and relative variability increased in the case of jute, (iii) absolute variability increased but relative variability decreased in the case of Boro rice and wheat. Finally they reported that production variability decreased in Bangladesh agriculture with the adoption of modern technology.

Crop production variability has deleterious effects on the farmers and the poor consumers, as well as on the national economy of Bangladesh. It may create problem in the attainment of food self-sufficiency goal, may discourage farmers to adopt new technologies and it may cause year to year fluctuations in production. This fluctuation in production may destabilize farm incomes and consequently this can have serious destabilizing impact on the national income, employment and balance of payments.

The present study was undertaken with a view to identify and analyzing the magnitude of foodgrain production variability and its sources with special emphasis on the role of privatization policies related to modern technology. The specific objectives of the study were as follows:

(i) To determine the magnitude of variability in area, yield and production of major foodgrains in Bangladesh at national and regional levels between the periods 1979/80 - 1988/89 and 1989/90-1998/99.

(ii) To analyze the sources of variability in major foodgrain production with special emphasis on privatization policies related to modern technology and their magnitude; and contribution *of* different regions and inter-regional covariance tochange in production variability.

The reminder *of* this paper has been organized as follows: Section II discusses the sources of data and analytical procedures of the study. The magnitude of variability in area, yield and production of different foodgrains are discussed in Section III. Section IV examines sources of variability in production with special emphasis on privatization policies related to modern technology and their magnitude; and contribution of different regions and interregional covariance to change in production variability at national level. Some concluding observations are made in section V.

II. METHODOLOGY

The data required for this study relate to aggregate (national) and district (regional) level data oF major foodgrain crops (Aus rice, Aman rice, Boro rice and wheat). The data used here were collected from the published documents of the Bangladesh Bureau of Statistics (BBS). Data relating to the 1979/80-1998/99 were obtained from BBS (1985, 1987, 1989, 1993, 1997 and 2001). These data were however checked with other published and unpublished data sources and corrected when major errors were detected.

Magnitude of changes in production variability and their sources for major foodgrainsAus rice, Aman rice, Boro rice and wheat were measured between the two time periods. The first period was before full-implementation of privatization policies which covered the period from 1979/80-1988/89 and the second period was after full-implementation of privatization polices, covering the period from 1989/90 to 1998/99. Analysis was done both at national and regional levels. In this study, the country was disaggregated into 21 regions, which considered with the former 23 districts. The regions are: Chittagong, Chittagong Hill Tracts (Rangamati, Bandarban, Khagrachari), Comilla, Noakhali, Sylhet, Dhaka, Faridpur, Jamalpur, Kishoreganj, Mymensingh, Tangail, Borisal, Jossore, Khulna, Kushtia, Patuakhali, Bogra, Dinajpur, Pabna, Rajshahi and Rangpur. In the case of wheat, Chittagong, Chittagong Hill Tracts, Noakhali, Barisal, Khulna and Patuakhali districts have been considered together as `Other regions' due to their small figures.

Absolute and relative changes in area, yield and production variability were measured in the study. For measuring instability in area, production and yield of the selected foodgrain crops, their changes in standard deviation by regions were at first estimated between the two periods. Of the various measures of absolute dispersion, standard deviation was used because it is the most suitable method for measuring deviations in time series data (Croxton et. al., 1975). The standard deviation is an absolute measure of dispersion, hence the corresponding relative measure i.e., coefficient of variation was used to measure the instability and its change between the two periods. The sum of square of the deviations of each observation from the mean of the observations was used to compute the coefficient of variation (C.V.).

$$C.V. = \frac{SD}{\bar{X}} \times 100$$

Where,

SD is the standard deviation

$\bar{X}$ is the mean of observations.

To analyze the sources of changes in foodgrain production variability Hazell's Variance Decomposition Procedure (1982) was used. Production variance was calculated to interpret the result of the model. To use this model following adjustments were taken: The area and yield data for each crop and region were de-trended using linear relations of the form

$Z_t = a + bt + e_t$..(i)

Where Z_t denotes the dependent variable (area or yield), t is time and e_t is a random residual with a zero mean and variance σ^2. Separate regressions were run for each of the two time periods to ensure that $\sum_t e_t = 0$ for each period.

After detrending the residuals were centered on the mean areas or yields for each period, $\bar{Z}$, resulting in detrended time-series data of the form

$$Z = e_t + \bar{Z}$$

Time series data on de-trended production for each crop and region were then calculated as the product of the de-trended areas and yields.

Following Hazell's model, the variance of production of a particular crop can be expressed as:

$$V(Q) = \sum_{i=1 i \neq j}^{21} \sum_{j=1}^{21} \text{cov}(AiYi, AjYj) \quad \text{..(1)}$$

where, A denotes area under cultivation in ha; Y denotes yield (metric ton/ha); i and j denotes regions and this can be partitioned as:

$$V(Q) = \sum_{j=1}^{21} V(A_j Y_j) + \sum_{j=1}^{21} \sum_{i=1_{i \neq j}}^{21} Cov(A_i Y_i, A_j Y_j) \quad \text{..........................(2)}$$

In words, V(Q) = [sum of the variances within regions]

(i = j)

+ [sum of interregion Covariances of the crop]

($i \neq j$)

The variance of production of a particular crop, therefore, depends not only on the production variances of the respective crop in each region, but also on Covariances between the production in different regions.

Following Bohrnsted and Goldberger (1969) the inter-crop or inter-region production covariance's can be measured for the first period as:

$$\mathrm{Cov}\,(A_{Ii}Y_{Ii}\,,\,A_{Ij}Y_{Ij}) = \bar{A}_{Ii}\,\bar{A}_{Ij}\,\mathrm{Cov}\,(Y_{Ii}\,Y_{Ij}) + \bar{A}_{Ii}\,\bar{Y}_{Ij}\,\mathrm{Cov}\,(Y_{Ii},\,A_{Ij})$$
$$+\,\bar{Y}_{Ii},\bar{A}_{Ij}\,\mathrm{Cov}\,(A_{Ii},\,Y_{Ij}) + \bar{Y}_{Ii},\bar{Y}_{Ij}\,\mathrm{Cov}\,(A_{Ii},\,A_{Ij})$$
$$-\;\mathrm{Cov}\,(A_{Ii},Y_{Ii})\,\mathrm{Cov}(A_{Ij},Y_{Ij}) + R_I \qquad \text{.....(3)}$$

and for the second period as:

$$\mathrm{Cov}\,(A_{IIi}\,Y_{IIi},\,A_{IIj}\,Y_{IIj}) = (\bar{A}_{Ii}+\Delta\bar{A}_i)(\bar{A}_{Ij}+\Delta\bar{A}_j)[\mathrm{Cov}\,(Y_{Ii},Y_{Ij}) + \Delta\,\mathrm{Cov}\,(Y_i\,,Y_j)]$$
$$+\,(\bar{A}_{Ii}+\Delta\bar{A}_i)(\bar{Y}_{ij}+\Delta\bar{Y}_j)\,[\mathrm{Cov}\,(Y_{Ii},A_{Ij}) + \Delta\,\mathrm{Cov}\,(Y_i,A_j)]$$
$$+\,(\bar{Y}_{Ii}+\Delta\bar{Y}_i)(\bar{A}_{ii}+\Delta\bar{A}_j)[\mathrm{Cov}\,(A_{Ii},Y_{Ij}) + \Delta\,\mathrm{Cov}\,(A_i\,,Y_j)]$$
$$+\,(\bar{Y}_{Ii}+\Delta\bar{Y}_i)(\bar{Y}_{ij}+\Delta\bar{Y}_j)[\mathrm{Cov}\,(A_{Ii},Y_{Ij}) + \Delta\,\mathrm{Cov}\,(A_i\,,A_j)]$$
$$-[\mathrm{Cov}\,(A_{Ii},Y_{Ii}) + \Delta\,\mathrm{Cov}\,(A_i\,,Y_i)]\,[\mathrm{Cov}\,(A_{Ij},A_{Ij})$$
$$+\,\Delta\,\mathrm{Cov}\,(A_j\,,Y_j)] + (R_I\;\Delta R) \qquad \text{.....(4)}$$

The change in the covariance between the two periods can be calculated as {equation (4)-equation (3)} = $\Delta\,\mathrm{Cov}\,(A_iY_i,\,A_jY_j)$. The term in this expression has been described in Table 1 so that they can be attributed to different sources.

Now, the change in variance of production, $\Delta\,V(Q)$, is decomposed by applying the decomposition results in Table 1 to each of the covariance terms in equation (1). The components of change is then aggregated as grouped in equation (2). A detail description of this method is given in Akter (2002).

Contribution of crops and regions to change in variance of production are as follows: Contribution of different crops to change in production variance of total foodgrain was estimated by using equation (5)

$$\begin{bmatrix}\text{Contribution of}\\ \text{i th crops to}\\ \text{change in}\\ \text{production}\\ \text{variance of total}\\ \text{foodgrains}\end{bmatrix} = \frac{\Delta V_i}{\sum_{i=1}^{4}\Delta V_i} = \frac{\text{Change in production variance of crop i}}{\text{Change in production variance of total foodgrain}} \qquad (5)$$

Where, ΔV denotes change in production variance and i denotes different crops. Contribution of different regions to change in production variance in a crop was estimated by using equation (6).

$$\text{[Contribution of j th regions change in production variance of variance of crop i]} = \frac{\Delta V_j}{\sum_{j=1}^{22} \Delta V_j} = \frac{\text{Change in production variance in region j}}{\text{Change in production variance of Bangladesh}} \qquad (6)$$

Where ΔQ denotes change in production variance and j denotes different regions.

Table 1 Components of Change in the Variance of Production

Source of Change		Components of Change
Description	Symbol	
Change in mean yield	$\Delta \bar{Y}$	$2\bar{A}_I \Delta \bar{Y}$ Cov (Y_I,A_I) $+[2\bar{Y}_I \Delta \bar{Y} + (\Delta \bar{Y})^2]V(A_I)$
Change in mean area	$\Delta \bar{A}$	$2\bar{Y}_I \Delta\bar{A}$+Cov (Y_I,A_I) $+[2\bar{A}_I \Delta \bar{A}_I + (\Delta \bar{A}_I)^2]V(Y_I)$
Change in yield variance	$\Delta V(Y)$	$(\bar{A}_I)^2 \Delta V(Y)$
Change in area variance	$\Delta V(A)$	$(\bar{Y}_I)^2 \Delta V(A)$
Interaction between changes in mean area and mean yield	$\Delta \bar{Y}, \Delta \bar{A}$	$2\Delta \bar{Y} \Delta \bar{A}$ $Cov(Y_I,A_I)$
Change in area-yield covariance	Δ Cov (Y,A)	$[2\bar{A}_I \bar{Y}_I - 2 Cov(Y_I,A_I)]$ $\Delta Cov(Y,A) - [\Delta Cov(Y,A)]^2$
Interaction between changes in mean area and yield variance	$\Delta \bar{A}, \Delta V(Y)$	$[2\bar{A}_I, \Delta \bar{A} + (\Delta\bar{A})^2]$ V(Y)
Interaction between changes in mean yield and area variance	$\Delta \bar{Y}, \Delta V(A)$	$[2\bar{Y}_I, \Delta \bar{Y} + (\Delta \bar{Y})^2]V(A)$
Interaction between changes in mean area and yield and changes in area-yield covariance	$\Delta \bar{Y}, \Delta \bar{A}, \Delta Cov(Y,A)$	$[2\bar{Y}_I \Delta \bar{A} + 2\bar{A}_I + \Delta \bar{Y} +$ $2\Delta \bar{A} \Delta \bar{Y}] \Delta Cov(Y,A)$
Change in residual	ΔR	$\Delta V(AY)$-sum of the other components

Note: 'A' denotes area sown, 'Y' yield and 'V' variance.

III. MAGNITUDE OF CHANGES IN AREA, YIELD AND PRODUCTION VARIABILITY OF FOODGRAINS AT NATIONAL AND REGIONAL LEVELS

This section describes changes in area, yield and production variability of foodgrains at national and regional levels in Bangladesh. Absolute change in area, yield and production variability, measured in terms of Standard Deviation. Table 2 indicates that absolute area variability of Bangladesh increased in Aus, wheat and total foodgrains in the second period by about 59, 58 and 16 percent respectively. But in the case of Aman and Boro it decreased by about 36 and 23 percent respectively. This is true for most of the regions.

Table 2. **Percentage Changes in Standard Deviation of Area between the Periods 1979/80-198889 and 1989/90-1998/99 by Crops and by Regions (in percent)**

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	-55.46	-36.77	-13.18	-	70.39
Chittagong H.T	-90.43	-42.29	-58.46	-	-64.52
Comilla	-18.12	3G.25	-5G.24	11.26	46.25
Noakhali	-16.74	-46.13	3.37	-	1.27
Sylhet	16.74	-47.47	22.58	-	-23.98
Dhaka	-24.24	-41.42	-74.84	-60.58	-2.90
Faridpur	-21.42	24.07	-49.48	-23.98	-44.44
Jamalpur	-46.82	-27.06	-29.14	44.98	-31.30
Kishorgonj	-67.83	-55.52	-6.65	-37.97	-24.71
Mymensingh	41.93	-58.86	31.14	-G5.60	-38.25
Tangail	-58.91	-58.93	-27.33	26.89	-72.52
Barisal	-33.75	55.12	11.07	-	35.90
Jessore	2.29	-5.43	-38.59	25.98	-38.74
Khulna	-4.28	183.96	38.31	-	185.39
Kushtia	34.53	-53.16	128.88	-14.27	-59.98
Patuakhali	-56.53	-53.02	-29.31	-	-52.78
Bogra	-82.10	-61.30	-64.68	-42.84	-11.36
Dinajpur	-8.87	151.96	126.27	71.67	106.73
Pabna	-57.97	-72.37	-39.74	51.9s9	-53.27
Rajshahi	-17.95	-67.94	-16.26	33.89	-35.11
Rangpur	-35.24	23G.15	-14.84	26.86	74.02
Other regions*	-	-	-	-21.98	-
Bangladesh	59.41	-35.G3	-23.23	57.93	15.74

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.

Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

It is found from Table 3 that absolute yield variability of Bangladesh reduced in the second period in the case of Aus, Aman and total foodgrains by about 23, 20 and 1 percent respectively. But yield variability of Boro and wheat increased by about 59 and 29 percent respectively.

Absolute change in production instability is presented in Table 4. It indicates that production instability at national level increased in the second period for all foodgrains. In the case of Aus, production instability increased by about 50 percent at national level but it declined in all the regions except Comilla, Sylhet and Khulna. Production instability of Aman, Boro, wheat and total foodgrains increased by about 19, 28, 105 and 4 percent respectively at national level. This is true for most of the regions.

Table 3 Percentage Changes in Standard Deviation of Yield between the Periods 1979/80-1988/89 and 1989/90-1998/99 by Crops and by Regions (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	100.08	7.22	28.89		118.85
Chittagong H.T	-68.10	-52.10	-4.17	-	-66.3'G
Comilla	-0.21	-56.59	20.69	-6.43	-60.85 '
Noakhali	-36.10	110.40	A5.21	-	63.83
Sylhet	-42.84	-5.52	54.75	-	G7.20
Dhaka	-0.G3	58.92	22.88	-15.79	207.76
Faridpur	-22.85	-1.05	-18.44	-22.46	-16.50
Jamalpur	15.53	-20.41	-40.23	-G5.04	5.30
Kishorgonj	-20.30	14.34	15.99	42.06	-27.75
Mymensingh	-2.39	39.40	-16.39	-71.62	3G.00
Tangail	-18.78	54.56	-39.59	-29.20	-11.61
Barisal	-7.52	67.73	57.63	-	136.30
Jessore	15.G1	-55.37	77.39	-16.75	-0.94
Khulna	106.59	3.63	9.43	-	8.G9
Kushtia	-67.73	-36.28	-50.16	14.24	3.89
Patuakhali	-10.48	54.29	78.71	-	28.34
Bogra	171.20	67.95	29.55	-14.19	-60.66
Dinajpur	80.37	G1.58	94.G8	50.95	-46.16
Pabna	-26.90	50.57	-42.33	-11.61	9.66
Rajshahi	56.78	34.11	11.8G	32.33	29.3G
Rangpur	-47.13	124.07	79.71	106.57	9.59
Other regions*	-	-	-	165.33	-
Bangladesh	-23.44	-20.37	58.99	28.59	-1.13

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.
Note: ** Other regions included chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

Empirical evidence on the changes in relative variability of area, yield and production of major foodgrains at national and regional levels, measured in terms of coefficient of variation (CV) between the two periods are presented in Tables 5, 6 and 7. It is found from Table 5 that the CV of area increased for Aus, wheat and total foodgrains and decreased for Aman and Boro in the second period at national level.

Table 6 presents that the CV of Yield decreased for Aus, Aman and total foodgrains: and increased for Boro and wheat in the second period at national level.

Table 4 Percentage Changes in Standard Deviation of Production between the Periods 1979/80-1988/89 and 1989/90-1998/99 by Crops and by Regions (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	-34.39	-48.54	225.18	-	G8.66
Chittagong H.T	-57.39	-23.66	-38.54	-	-20.26
Comilla	16.65	-24.53	-32.07	-26.65	-73.43
Noakhali -	-2.39	63.87	44.17	-	-20.54
Sylhet	10.99	-17.24	107,0G	-	85.79
Dhaka	-25.05	-25.42	18.50	-31.47	1.74
Faridpur	-42.16	27.98	-35.49	-13.41	-55.59
Jamalpur	-38.98	29.17	9.'52	35.14	61.75
Kishorgonj	-50.61	7.75	44.3G	0.44	19.79
Mymensingh	-2.47	3.12	73.79	-5G.18	13.89
Tangail	-60.06	-33.39	-10.75	95.97	-47.03
Barisal	-25.48	G1.3G	66. f4	-	102.31
Jessore	-20.87	10.49	18.62	97.45	-5.85
Khulna	10.03	2.50	75.80	-	19.30
Kushtia	-33.07	-46.2G	125.91	20.98	-23.37
Patuakhali	-35.96	23.87	12.30	-	-8.44
Bogra	-73.73	53.84	-40.03	-33.15	-44.50
Dinajpur	-2.95	59.24	174.8G	169.68	49.57
Pabna	-49.84	-48.2G	-8.79	140.20	53.63
Rajshahi	-30.G0	42.55	39.09	63.99	64.08
Rangpur	-53.49	219.30	31.21	49.G3	28.80
Other regions*	-	-	-	-11.53	-
Bangladesh	50.25	18.5G	28.38	105.37	4.12

Source: Calculated from Bangladesh Bureau of Statistics (-1 L53Various Issues) data.

Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

Relative change in production variability is presented in Table 7. CV of different crops in the second period at national level increased for Aus, Aman and wheat; and declined for Boro and total foodgrains. This implies that relative production instability increased for Aus, Aman and wheat; and declined for Boro and total foodgrains in the second period. It is known that production is an ultimate effect of area and yield. Change in production instability of Aus is positive due to significant positive change in area instability. Change in production instability of Aman is positive, although changes in area and yield instability are negative. CV of Aman increased in the second period at national level may be due to other factors. Table 7 also represents that production variability of Boro reduced due to negative area instability in the second period. Change in production instability of wheat is positive due to positive changes in area and yield variability. In the case of total foodgrains, production instability reduced due to negative change in yield variability.

Table 5 Percentage Changes in Coefficient of Variation of Area between the Periods 1979/80-1988/89 and 1989/90-1998/99 by Crops and by Regions (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	24.40	-40.95	-19.53	-	71.64
Chittagong H.T	-87.39	-45.91	-57.60	-	-G1.72
Comilla	32.73	39.83	-75.69	50.14	45.34
Noakhali	13.55	-40.89	-34.60	-	6.08
Sylhet	16.98	-45.36	4.22	-	-26.30
Dhaka	60.93	-16.79	-84.85	-67.51	10.80
Faridpur	-1.16	54.06	-71.05	-42.00	-39.33
Jamalpur	5.64	_	-62.25	4.94	-26.16
Kishorgonj	-45.02	-47.42;	-33.37	-69.11	-26.26
Mymensingh	130.08	-56.05	-28.16	-77.05	-34.95
Tangail	-15.92	-44.57	-45.26	9.23	-66.06
Barisal	-19.71	62.02	-18.88	-	43.99
Jessore	98.38	-20.62	-80.88	-11.18	-44.43
Khulna	29.03	190.74	-30.23	-	182.07
Kushtia	110.94	-68.38	-57.35	-16.16	-61.03
Patuakhali	-51.37	-56.83	-12.30	-	-54.69
Bogra	55.80	-60.37	-86.02	-24.81	-17.50
Dinajpur	171.93	124.30	-51.38	7.92	90.43
Pabna	40.74	-63.42	-69.50	-17.26	-47.50
Rajshahi	29.73	-67.07	-68.47	8.96	-40.74
Rangpur	99.87	218.82	-67.34	34.69	82.42
Other regions*	-	-	-	-28.79	-
Bangladesh	171.58	-33.68	56.40	30.09	16.76

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.

Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

IV. SOURCES OF CHANGE IN VARIANCE OF FOOGGRAINS PRODUCTION IN BANGLADESH AND THEIR MAGNITUDE

Absolute change in production variability, also measured in terms of production variance for different crops at national and regional level are presented in Table 8. It indicates that production variance increased about 7 and 290 percent in Aman and Boro rice respectively at the national level. For these two crops, production variance also increased in most of the regions. But production variance decreased in Aus rice, wheat and total foodgrains by about 43, 71 and 79 percent at national level. This is true for almost all the regions.

This section also describes the components of change in variance of foodgrains production under study. The magnitude and direction of changes in variance of production of different crops as well as their sources are summarized in Table 9. The last row of Table 9 is the reproduction of the last row of the Table 8. Positive signs of the value of the last row imply increases in variance and negative signs imply decreases in variance. The first ten rows of Table 9 show the decomposition of the total change in the variance assuming the total change as 100. As variance of Aus, wheat and foodgrains production decreased, negative values of the sources of production of these crops imply that the corresponding sources have destabilizing effect. It also shows as variance of Aman and Boro rice production increased, negative values of the sources of production of these crops imply that the corresponding sources have stabilizing effect.

Table 6 Percentage Changes in Coefficient of Variation of Yield between the Periods 1979/80-1988/89 and 1989/90-1998/99 by Crops and by Regions (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	G8.14	-10.06	39.52	-	95.49
Chittagong H.T	-71.71	-58.36	2.52	-	-70.17
Comilla	-10.93	-65.59	15.06	-13.69	-69.21
Noakhali	-27.89	81.95	76.83	-	41.42
Sylhet	-53.80	-26.54	41.74	-	37.93
Dhaka	12.64	45.43	14.88	-22.29	137.08
Faridpur	-33.37	-19.46	-23.51	-12.81	-36.37
Jamalpur	31.65	-34.01	-47.65	-67.69	-19.46
Kishorgonj	-32.70	-5.09	3.65	46.03	-42.05
Mymensingh	2.49	32.59	-34.33	-64.82	15.37
Tangail	-2.79	25.95	39.43	-22.26	-28.20
Barisal	-3.43	G3.25	42.12	-	123.47
Jessore	-15.57	-68.87	52.24	-18.76	-36.63
Khulna	46.91	-14.35	-3.25	-	-12.75
Kushtia	-74.54	-52.99	-55.30	20.25	-21.85
Patuakhali	-28.29	53.75	38.63	-	22.18
Bogra	148.05	36.85	29.75	-19.35	-70.48
Dinajpur	80.5G	37.00	91.12	44.67	-58.14
Pabna	-25.51	11.96	-47.07	-4.77	-24.12
Rajshahi	11.17	-4.85	-3.48	29.58	-13.55
Rangpur	-59.71	92.58	G2.77	104.58	-19.93
Other regions*	-	-	-	152.35	-
Bangladesh	-31.89	-34.27	42.48	30.01	-22.74

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.
Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

Table 10 shows the contribution of different regions and inter-regional covariance to the change in production variance for the country. If a region contributes positively (negatively) to the decrease (increase) in the total variance of national production of a crop production, negative (positive) values of the components of changes in variances imply their destabilizing (stabilizing) effect.

4.1 Aus

Table 9 and 10 present the components of change in production variance of Aus. Among the regions Rangpur region contributed about 50 percent in the case of reduction of Aus production variance (Table 10). Kishoreganj, Barisal, Jossore and Rajshahi regions in combination contributed about 21 percent of the reduction. Except Comilla, Sylhet and Mymensingh regions, all the regions contributed positively to the reduction of production variance. Comilla, Sylhet and Mymensingh regions contribution was negative. This means that these regions had destabilizing effect on production variance. Inter-regional covariance contributed positively to the reduction in Aus production variance by about 21 percent which means that it decreased production variance.

Table 7 Percentage Changes in Coefficient of Variation of Production between the Periods 1979/80-1988/89 and 1989/90-1998/99 by Crops and by Regions (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	-6.18	-59.56	223.68	-	52.03
Chittagong H:T	-52.10	-37.96	-32.75	-	-24.38
Comilla	67.48	-38.89	-63.87	-8.03	-79.20
Noakhali	48.51	55.54	-13.17	-	-27.85
Sylhet	-10.28	-33.08	60.63	-	48.33
Dhaka	77.49	-3.07	-33.93	-47.47	-10.34
Faridpur	-36.29	28.63	-64.94	-18.92	-62.66
Jamalpur	37.26	22.83	-48.19	-10.59	32.33
Kishorgonj	-29.26	4.97	-7.98	-49.68	-6.19
Mymensingh	66.24	4.77	-24.09	-65.55	1.76
Tangail	-2.73	-27.79	-32.35	81.32	-47.36
Barisal	-5.75	63.55	7.29	-	101.99
Jessore	13.53	-35.73	-66.21	31.50	-45.26
Khulna	8.14	-13.11	-21.03	-	-5.23
Kushtia	-16.54	-72.82	-50.92	23.66	-43.59
Patuakhali	-43.30	13.54	8.33	-	-16.45
Bogra	86.83	27.84	-76.57	-17.49	-61.23
Dinajpur	192.38	20.89	-43.93	59.61	7.11
Pabna	68.37	-48.92	-56.91	36.09	18.29
Rajshahi	-20.51	3.38	-55.36	29.29	-0.03
Rangpur	10.44	159.70	-55.32	57.37	-1.38
Other regions*	-	-	-	-15.73	-
Bangladesh	127.88	0.66	-34.68	68.99	-17.91

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.

Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

At the national level, interaction between changes in mean area and yield variance, change in mean yield, and change in mean area variance have destabilizing effect on Aus production (Table 9). Change in mean area was the major source of variation of Aus production. It had a positive contribution to the reduction of Aus production variance in the country or it stabilizes Aus production.

Table *8* Percentage Changes in Variance of Production between the Periods *1979/801988/89* and *1989/90-1998/99* (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	-19.80	-44.97	652.70	-	-83.50
Chittagong H.T	-79.42	-86.36	-84.36	-	-89.63
Comilla	26.91	-51.57	-38.73	-87.67	-69.59
Noakhali	-1G.GG	170.72	228.19	-	-77.70
Sylhet	26.19	-76.85	-5.40	-	-86.82
Dhaka	-90.81	-39.82	32.43	-90.32	-81.12
Faridpur	-34.03	59.38	45.32	-88.26	-59.0G
Jamalpur	-91.32	95.89	2G9.58	-5.27	-85.58
Kishorgonj	-87.99	50.22	-16.07	-57.14	-84.20
Mymensingh	24.52	-14.5G	859.99	-G3.04	-83.38
Tangail	75.67	-25.49	-45.02	-62.33	-88.50
Barisal	-81.8G	52.39	518.G8	-	-71.14
Jessore	-47.81	162.90	59.78	-58.70	-65.21
Khulna	-11.28	-19.75	550.43	-	-73.61
Kushtia	-55.01	7.70	1041.33	-74.55	-74.87
Patuakhali	-69.77	13G.03	105.1G	-	-82.90
Bogra	-59.35	42.59	-34.64	-85.23	-67.50
Dinajpur	-49.55	25G.34	797.G0	-8G.25	-71.84
Pabna	-78.95	-53.50	359.39	-25.49	-83.89
Rajshahi	-79.32	142.04	397.25	-87.72	-G9.8G
Rangpur	-97.59	1154.28	130.11	-1.28	-80.07
Other regions*	-	-	-	150.28	-
Bangladesh	-43.17	6.96	289.98	-70.G1	-78.G4

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.
Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

4.2 Aman

As it was discussed earlier, the variance of Aman production increased only to a small extent (about 7 percent) over the period (Table 9). Inter regional covariance contributed negatively to increase in Aman production variance which means that it decreased Aman production variance (Table 10). Among the regions, Rangpur region contributed about 86 percent to increases in production variance. Noakhali, Danajpur and Rajshahi regions also made large contribution to increase production variance or to destabilize Aman production. Chittagong, Chittangong H.T. Comilla, Sylhet, Dhaka, Mymensingh, Tangail, Khulan and Pabna regions contributed negatively to increase in production variance. This means that these regions had a stabilizing impact on variance.

Among the sources of production variance, change in area-yield covariance and change in mean yield had destabilizing effect on the production variance in the country as a whole (Table 9). Change in mean area variance and change in mean yield variance appeared to be a leading stabilizing factor in Aman production.

Table 9 Components of Change in the Variance of Production of Individual Crops in Bangladesh between the Two periods 1979/80-1988/89 and 1989/90-1998/99 (in percent)

Source of Change		Aus	Aman	Boro	Wheat	Total Foodgrain
Description	Symbol					
Change in mean yield	$\Delta \bar{Y}$	-18.70	455.49	50.07	-46.57	-33.2
Change in mean area	$\Delta \bar{A}$	106.73	-143.20	86.23	-110.49	0.69
Change in yield variance	ΔV(Y)	35.47	-566.62	-9.75	151.42	0.56
Change in area variance	ΔV(A)	-15.62	-649.97	-45.42	64.90	101.68
Interaction between changes in mean area and mean yield	$\Delta \bar{Y}, \Delta \bar{A}$	1.52	-1.25	0.38	9.33	0.00
Change in area-yield covariance	Δ Cov (Y,A)	26.12	922.00	-24.49	-67.23	-0.17
Interaction between changes in mean area and yield variance	$\Delta \bar{A}$, Δ V(Y)	-23.25	32.75	-20.48	71.73	-0.16
Interaction between changes in mean yield and area variance	$\Delta \bar{Y}$, Δ V(A)	-4.13	-171.23	11.97	36.24	-26.79
Interaction between changes in mean area and yield and changes in area-yield covariance	$\Delta \bar{Y}, \Delta \bar{A}$, Δ Cov(A, Y)	-8.89	83.98	-23.98	-34.50	0.01
Change in residual	ΔR	0.73	138.04	-15.37	25.17	3.82
Change in variance of production in Bangladesh	-	-43.17	6.96	289.98	-70.61	-78.64

Source: Author's calculation based on data gathered from Bangladesh Bureau of Statistics (Various Issues).

4.3 Boro

The principle contributor to variance of Boro production was inter-regional covariance, accounting to about 95 percent change in variance at the national level (Table 10). Chittagong H.T, Comilla, Sylhet, Kishoreganj, Tangail and Bogra regions contributed negatively to the increase in production variance which means that these regions had stabilizing impact on production variance. Except these regions all other regions contributed to destabilize production variance. Change in mean yield, change in mean area and change in mean area variance have destabilizing effect on Boro production (Table 9). Change in area-yield covariance contributed negatively to increase in production variance by about 24 percent which means stabilizing effect on Boro production.

4.4 Wheat

As it was discussed earlier, the variance of wheat production decreased by about 71 percent. Table 10 reveals that the production variance decreased due to inter-regional covariance and it contributed about 50 percent of the change. All the regions except other regions had a positive contribution to this change which means stabilizing impact on wheat production. Among the regions, Dinajpur was the largest contributor to stabilizing production variance.

Among the source of production variance change in mean yield variance was the major component to decrease or stabilize wheat production variance (Table 9). Change in mean area largely contributed to destabilize production variance.

4.5 Total Foodgrains

Tables 9 and 10 present the components of change in production variance of total foodgrains. Inter-regional covariance was the principle contributor (about 95 percent) to
decrease in production variance (Table 10). All the regions had stabilizing impact on total foodgrains production variance, but the contribution of these regions was very little to national production variance.

Table 10 Contribution of Different Regions and Inter-regional covariance to the change in Production Variance of Different crop betwpen the Periods *1979/80-1988/89* and *1989/90-1998/99* (in percent)

Regions/Crops	Aus	Aman	Boro	Wheat	Total Fodgrains
Chittagong	0.30	-3.98	0.33	-	0.34
Chittagong H.T	0.07	-0.18	-0.004		0.01
Comilla	-0.83	-22.70	-0.39	2.13	0.42
Noakhali	0.74	17.89	0.52	-	0.22
Sylhet	-2.30	-18.75	-0.02	-	0.73
Dhaka	2.87	-5.10	0.16	1.02	0.34
Faridpur	1.47	3.20	0.25	3.34	0.08
Jamalpur	0.77	3.04	0.33	0.002	0.12
Kishorgonj	3.88	2.40	-0.10	0.18	0.35
Mymensingh	-0.26	-1.53	0.64	0.05	0.24
Tangail	0.25	-2.16	-0.19	0.09	0.14
Barisal	6.99	4.40	0.36		0.22
Jessore	4.16	9.72	0.46	0.77	0.15
Khulna	0.17	-3.47	0.13	-	0.17
Kushtia	1.42	0.05	0.06	1.68	0.04
Patuakhali	1.25	7.84	0.01	-	0.08
Bogra	0.84	3.63	-0.08	0.74	0.16
Dinajpur	1.02	16.74	0.85	36.85	0.26
Pabna	0.77	-5.03	0.47	0.59	0.12
Rajshahi	5.65	13.63	0.58	2.54	0.31
Rangpur	49.74	86.13	0.71	0.05	0.97
Other regions*	-	-	-	-0.11	-
Inter-regional covariance	21.04	-5.78	94.92	50.08	94.53
Bangladesh	100	100	100	100	100

Source: Calculated from Bangladesh Bureau of Statistics (Various Issues) data.
Note: ** Other regions included Chitagong, Chitagong H.T, Noakhali, Sylhet, Barisal, Khulna and Patuakhali. It is only valid for wheat.

Apart from interaction term, change in mean area variance appeared to be a leading stabilizing factor in variance of total foodgrains production (Table 9). Change in mean yield contributed negatively to the reduction of production variance. This means it had destabilizing effect on production variance.

V. SUMMARY AND CONCLUSIONS

The findings of this research showed that both the absolute variability (Standard Deviation, SD) and relative variability (Coefficient of Variation, CV) increased in the cases of Aus rice, Aman rice and wheat production during the period After Full-Implementation of Privatization Policies (AFIPP); and absolute variability increased but relative Variability decreased during AFIPP period in the cases of Boro rice and total foodgrains. The increase in CV of Aman rice and wheat production is due to increase in both SD and average production of Aman rice and wheat. The increase in relative variability of Aus rice is due to increase in absolute variability (SD) and decrease in average production of Aus. The decrease in CV of Boro rice and total foodgrains production is attributed to increase in both SD and average production of Boro rice and total foodgrains.

It was also found that absolute and relative area variability increased in the cases of Aus rice, wheat and total foodgrains; and decreased in the cases of Aman and Boro rice during AFIPP period. Absolute and relative yield variability increased in the cases of Boro rice and wheat; decreased in the cases of Aus rice, Aman rice and total foodgrains during AFIPP period. The study also showed inter-regional covariance is the largest contributor to change in production variance of Aus rice, Boro rice, wheat and total foodgrains between the two periods. In the case of Aman rice, Rangpur region is the largest contributor to change in production variance.

Variance of Aus production decreased by 13 percent and CV of production increased by 128 percent during AFIPP period. Both production variance of Aman rice and CV of production increased by 7 and 1 percent respectively; both production variance of total foodgrains and CV of production decreased by 79 and 18 percent respectively. Variance of Borp rice production decreased by 35 percent, but CV of production increased by 290 percent during AFIPP period.

Thus the findings of the study confirm that the relative variability decreased for Boro rice and total foodgrains production with the full implementation of privatization policies related to modern technology. But relative production variability increased in the cases of Aus rice, Aman rice and wheat may not due to full implementation of privatization policies, but for different agro-climatic factors such as rainfall, flood, drought, severe insects and pest attack, etc.; political unrest, economic and institutional factors, government price policy, credit policy, the changing role of extension program, etc. may have significant influence on production variability which are not considered in this study. So it is suggested that planners and policy makers need not be worried about production variability with the full implementation of pre policies related to modern technology.

In order to increase foodgrain production and to reduce adverse effect of instability at national and regional levels, the important steps need to be taken are:

1. Government should emphasize more on privatization policy related to modern technology to increase efficiency and to reduce wastage of resources of this sector.
2. Promotion of research is needed to improve and adopt technology for foodgrains to reduce the adverse effects of instability and improving productivity. Research efforts should be strengthened to provide appropriate technology suitable to the socioeconomic and agro-ecological conditions of different regions of the country.
3. In the cases of high risk crops and high-risk regions Government should supply subsidized modern technology and should take measures to reduce risk.
4. Government should also take some programs to protect foodgrains from natural disasters, accelerate investment to the low productivity regions and providing modern technology to the farmers.

Limitation of the studv:

The studv encountered a number of limitations which can be listed as follows:

1. The study was conducted on the basis of official macro level statistics compiled and published by the Bangladesh Bureau of Statistics (BBS). But proper assessment of the production variability should ideally be based on individual farm level time series data. Such data set is not available.
2. Variety-wise (traditional and modern variety) analyses could give more accurate information about the contribution of modern variety to increase or decrease of instability in the period after full implementations of privatization policies related to modern technologies.
3. Different agro-climatic factors such as rainfall, flood, drought, sever insect and pest attacks etc., changes in irrigated area and fertilizer use rates, political unrest, economic and institutional factors, government policies such as price policy, credit policy etc., and the changing role of extension programs may have significant influence on production variability. However, these were beyond the scope of the studv.

The above limitations indicate that there is a wider scope for further research considering different agro-climatic factors, variety (traditional and modern variety), government price policy, credit policy, etc. and the changing role of extension programs.

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