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Research Note

PERFORMANCE OF CROP PRODUCTION IN BANGLADESH: GROWTH AND REGIONAL DISPARITIES

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ABSTRACT

The study examines the changing trends, growth rates, stability and regional variations of crop area, production and yield. Over time, the average size of farms has become smaller and smaller and the distribution of landholdings has also become more and more skewed a result of which is the increasing landless and near landless farms. But double and triple cropped lands are increasing. Production trends of major crops are also increasing. Production and productivity of rice are increasing in each decade and unstable growth rates were observed for production and productivity of wheat and potatoes. Higher production but very low productivity was observed for minor cereals, pulses and oilseeds. Area irrigated by modern method was increased higher rate, specially, from late eighties. Intensity of cropping is comparatively higher in southeast and northeast regions. Bogra, Jesore, Mymensingh, Comilla, Chittagong and Chittagong Hill Tracts show better position in agricultural development. Out of 20 former districts of Bangladesh, Chittagong Hill Tracts was the top position and khulna was on the second top position using indexing method based on the eight agricultural development indicators.

I. INTRODUCTION

Overall agricultural production in Bangladesh has steadily improved during the last three decades, principally, due to moderate increase in rice, wheat, tobacco, fibers, vegetables and potatoes. Crop is the dominant sector that contributes 77 per cent to the total value addition of agriculture and 27 per cent to gross domestic product (GDP) of Bangladesh (Hashem et.al, 1996). The quantitative information about the land utilization pattern, crop production structure, changing production trends of different agricultural products and the effects of technical change of agriculture are prerequisites for a better understanding for the study of agricultural growth as well as the economic development in Bangladesh. The measures of growth rate and instability are always helpful for research to consult available literature to assess the stock of knowledge and receive useful insight for future research in the particular topic. Analysis of growth in area, production and yield can be very useful for policy making since they help to underrate both the magnitude and direction of the changes which are taking place. Instability is one of the important decision parameters in development dynamics and more so in the context of agricultural production. Some studies (Mehra 1981, Hazell 1982 and Mitra 1990) indicated that the new farm technology has added to instability in production.

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The knowledge of the regional variations of agricultural production can serve as a useful preliminary guide to measure economic development. The phenomenon of agricultural development has been approximately conceptualized as a process, which improves the quality of life. It would be of interest to measure the level of agricultural development in agricultural sector at district level. Knowledge of the relative level of development in agricultural sector of a district will help to identify appropriate strategies of development. Choice of a large number of indicators would reflect the true picture of development in the agriculture. The most common and simple techniques for aggregating development indicators are the ranking and indexing. Kundu and Raza *(1982)* analysed the pattern of agricultural development with the help of a large number of indicators relating to productivity, technological inputs and agrarian relations. This is a need to study the regional disparities using agricultural indicators for the present situation of Bangladesh that helps the government in promoting the technology in the country.

Findings from this research may be helpful for planners and policy makers in order to bring about desired adjustment in acreage allocation and consequently in formulating strategies for the production of agriculture. This study uses the latest data available up to the year *1998-1999* which is designed to make an improvement over the previous studies e.g. Hossain *(1984),* Elahi *(1990),* Sabur ana Miah *(1996),* Alam *(1997)* and Alam (2000). With these perspectives in view, an attempt has been made to study the growth (compound growth rate per annum) and variability (instability index) of crop area, irrigated crop area, production and yield. The study also shows through light on the future scenario in the evaluation of the agricultural production. Before that an overview of the land utilization pattern, crop production structure and changing trends in production and productivity of various crops including effects of inputs used are studied for the last three decades. Finally, the regional variations in cropped area and cropping intensity and district level disparities using a number of agricultural development indicators have been studied.

II. METHODOLOGY

Secondary data were used for this study. Time series data relating to area, production, yield and other relevant agricultural statistics were obtained from various issues of the published reports Bangladesh Bureau of Statistics (BBS) of different years. Yield figure has been derived from total production in tons divided by total area in hectares from the data. Compound growth rate was computed using the method by Chand and Tewari *1991* and was tested according to the principles of Shaha *1997* and the detailed procedures are shown in Appendix L An index of instability was computed for examining the nature and degree of instability in area, production and yield of various crops and non-crops. The coefficient of variation (CV) of area / production / yield was used as the measures of variability. However, simple coefficient of variation does not take note of the trend component inherent in the time-series data. As an alternative, coefficient of variation around the trend rather than coefficient of variation around the mean (CV) were suggested by Cuddy and Della *(1978),* Parthasarathy

(1984), Gujanana and Sharma (1990) as a better measure of variability. The major estimation procedures such as effects of technical change, compound growth rates, instability index and projection are presented in Appendix L For analyzing on a regional basis 20 former districts of Bangladesh were grouped into four regions namely, southeast, northeast, southwest and northwest. This grouping was made on the basis of the climatic and hydrological condition of different districts. In addition to these the method of ranking and indexing and the statement of development indicators are presented below.

Ranking and indexing methods were adopted to arrive at levels of development of twenty districts. In the ranking methods districts were arranged in descending order of magnitude of each indicator and were assigned ranks from the highest value. The ranks for all indicators pertaining to each sector were aggregated to arrive at the total rank. The lowest value of the `rank total' indicates the highest level of development. The `rank total' may thus be expected to give some sort of guidance to indicate relative development of the districts (Sarker, 1999). In the indexing method, the value of each indicator was expressed as a percentage of the average value of twenty districts. The indices of the indicators for each sector were aggregated separately and the corresponding average for each district was calculated and considered as the index of development of each district. The district having a higher index value reveals a higher level of development.

A group of eight indicators relating to development of agriculture have been selected to examine the disparities in agricultural development of former districts in Bangladesh. Most of these indicators relate to adoption of modern technology in agriculture. The development indicators taken from agricultural sector are as follows: percentage of forest area to total geographic area (PFA), percentage of total cropped area to total geoegraphic area (PCA), percentage of net area sown to total geographic area (PNA), cropping intensity, percentage of irrigated area to total cropped area (PIC), productivity of rice (PR), productivity of wheat (PW) and percentage of area under high yielding varieties of rice (PAHR).

III. RESULTS AND DISCUSION

Land Utilization Pattern and Crop Production Structure

The land resource of Bangladesh totals about 14.84 million hectares and is cultivated with moderate intensity. About 59 per cent land were available for cultivation by 10.05 million households during 1983-84 because of very high population pressure, on an average farm size of 0.81 hectare along with a homestead area of 320 ^{M2}/farm. Agricultural census of 1996 revealed that cultivated land decreased 1 per cent per year from 1983-84 to 1996 whereas homestead land has increased by 3 per cent per year during the same period. This census also revealed that only 66 per cent land were available for cultivation and actually 48 per cent lands are cultivated by 11.8 million households, on an average farm size is of 0.61 hectare and per holding homestead area was 0.03 hectare (Table 1). Nearly 7.2 million hectare land was cultivated of which 42.6 per cent (3,063550 ha) were irrigated and 55 per cent (3,958,587 ha) were fertilized with chemical fertilizer i.e., 0.17 ha and 0.22 ha per holding

respectively. Irrigated land increased per year 7.4 per cent during 1983-84 to 1996 and 11.3 per cent during 1977 to 1996 (Table 1). Based on the total area in 1996-97, 52.9 per cent was under crop production in a given year, and an additional 2.6 per cent is fallow. These two categories constitute the total land area currently devoted to crops.

Table 1. Basic characteristics of landholdings

	1977		1983-84		1996	
Holdings ('000' number)	8,255		13,818		17,828	
Total						
Non farm	1998	(24.20)	3,773	(27.30)	6,030	(33.82)
Farm	6257	(75.80)	10,.45	(72.70)	11,798	(66.18)
Agricultural Labourers ('000' number)			5,495		6,401	
Cultivated area	7,883		8,157		7,192	
Total ('000' ha)						
Per holding (ha)	1.23		0.81		0.61	
Homestead area			391		534	
Total ('000' ha)						
Per holding (ha)			0.03		0.03	
Irrigated area			1,620		3,063	
Total ('000' ha)	976					
Per holding (ha)	0.12		0.16		0.17	
Fertilized area using chemical fertilizer	3,380				3,959	
Total ('000' ha)						
Per holding (ha)					0.22	
Average size of farm (ha)	1.42		0.93		0.70	

Source: Statistical Yearbooks of Bangladesh

The total amount of land in production (including fallow lands) increased slightly. The annual growth of land utilization highly fluctuated for various crops. In 1972-73 to 1979-80, changes in land utilization for rice production was 5.5 per cent, but in 1990-91 to 1998-99 the changes in land utilization were negative (Table 2) which does not indicate that rice production was decreasing. Because of high yield variety of rice, the farmers were getting more production of rice by using small unit of land. Then they were producing other crops in additional land. Increases in land utilization for wheat production were dramatic, between 19972-73 to 1979-80 and from 1980-81 to 1989-90, it increased by 0.68 per cent and currently (1990-91 to 1998-99) 47.2 per cent. For fruits and vegetable production, the land utilization was increasing rapidly i.e. the change between 1972-73 to 1998-99 was 63.4 per cent whereas the change of land utilization for potato production between 1972-73 to 1998-99 were 24.5 per cent. Acreage of pulses increased 5.4 per cent in 1972-73 to 1979-80, 124.0 per cent in 1980-81 to 1989-90 then decreased by 24.9 per cent in 1990-91 to 1998-99 (Table 2). So, it can be said that pulse production is decreasing at recent. The major declines in land uses took place in fibers i.e. jute, oilseeds and tobacco. On the contrary, oil seeds acreage increased during the period 1980-81 to 1989-90 than that of 1972-73 to 1979-80. Recently, oil seeds

acreage is decreasing because of decreasing production of oil seeds for using importing soybean oil.

Table 2. Changes in land utilization for crop production

	Changes in Land Utilization			
	1972-73 to 1979-80	1980-81 to 1989-90	1990-91 to 1998-99	1972-73 to 1998-99
Rice	5.5	1.6	-3.1	5.0
Wheat	260.8	0.2	47.2	635.0
Minor cereals	-25.7	466.7	-20.7	193.3
Total cereals	8.5	2.4	-0.5	13.4
Pulses	5.4	124.0	-24.9	74.2
Oil seeds	3.3	85.1	-10.4	69.8
Spices & Condo	0.7	2.1	1.4	-2.6
Sugar crops	13.3	33.5	-6.4	49.2
Fruits & Vegetables	15.3	26.2	12.9	63.4
Tobacco	-3.3	-3.1	-6.9	-12.1
Fibers	-15.8	-11.7	1.7	-43.1
Potatoes	18.2	-0.6	2.3	24.5

Source: Statistical Yearbooks of Bangladesh

Bangladesh is endowed with favourable climate and soils for the production of a variety of crops throughout the year. The crops in this country are grown throughout the year in three distinct cropping seasons. The winter crops are greater in number than the summer monsoon crops. During sixties the cropping intensity increased substantially due to rapid expansion of irrigation that helped multiple cropping. After the liberation war agricultural production declined for some years. An analysis of land utilization pattern and cropping intensity shows that out of cultivated cropped land, 36 per cent was single cropped, 51.2 per cent double cropped, 12.8 per cent triple cropped in 1997-98. These figures were 60.5, 33.9 and 5.6 respectively in 1972-73; 54.1, 38.0 and 7.9 respectively in 1980-81; and 40.3, 47.7 and 12.0 respectively in 1990-91. The results interpret that single cropped land is increasing and the double and triple cropped lands are increasing day by day. The marginal increase in cropping intensity was also due to the expansion in area under irrigation.

Table 3. Trends in land utilization pattern and cropping intensity

Year	Single cropped		Double cropped		Triple cropped		Net cropped area	Total cropped area	Cropping intensity
	Area	%	Area	%	Area	%			
1972-73	5116	60.5	2846	33.9	472	5.6	8394	12224	145.63
1980-81	4636	54.1	3254	38.0	672	7.9	8562	13160	153.70
1990-91	3294	40.3	3899	47.7	981	12.0	8174	14034	171.70
1997-98	2866	36.0	4085	51.2	1017	12.8	7968	14087	176.79

Source: Statistical Yearbooks of Bangladesh

The major crops grown in Bangladesh are rice, wheat, pulses, potatoes, jute, sugarcane and tobacco. Rice is the staple food crop in Bangladesh. It dominates the Bangladesh diet, accounting for an estimated 85 per cent of the average calorie intake and around 75 per cent of the average protein intake (World Bank, 1980). In terms of acreage, rice occupies around 80 per cent in 1970s and below 75 per cent in 1990s of the total cropped area and hence, the Bangladesh economy is often characterized as a rice economy. Average per capita rice production is 151 kg during 1974-75 to 1998-99 Table 4. However, in recent years wheat production in Bangladesh has increased significantly and there exits a potential for further increase in wheat production. Per capita production of wheat exhibits an increasing trend, whereas per capita production of sugar crops and fruits exhibit a decreasing trend. Per capita production of vegetables decreased dramatically in the mid-eighties. After that this figure exhibits stable condition until the late nineties. Per capita production of pulses and oil seeds were comparatively higher in the late eighties and nineties than the seventies and early eighties.

Table 4. Per capita production of major agricultural food items

Food items (kg.)	1974-75	1979-80	1984-85	1989-90	1994-95	1998-99	Average
Rice	153	150	147	160	142	155	151
Wheat	2	10	*15*	9	11	15	10
Pulses,	6	6	5	9	8	9	7
Oilseeds	22	20	19	14	16	15	18
Potatoes							
Vegetables	22	20	9	10	10	11	14
Sugar crops	91	76	73	69	65	60	72
Fruits	18	16	14	13	13	11	14

Source: Yearbooks of Agricultural Statistics of Bangladesh

Productivity Trend and Effect of Technical Change

Production of the most agriculture products has increased during the past decades. Despite the general upward trends is production, however few crops have demonstrated dramatic break through. Although rice production has, generally, increased. Area under modern variety (MV) of rice is increased by reducing the area under law yielding variety (LYV) whereas the total area under rice production remained almost same over the years (Buffes and Gautam, 2001). Wheat output has increased in the last decade that is the most significant change among all crops. Production of wheat increased up to mid-eighties and decreased afterwards but after the 1997-98 production increased steadily. But production of pulse remained almost same up to the year 1997-98. After Independence, pulse production was too small for domestic demand. Policy taken by Government for increasing pulse production, the dramatic changes occurred in pulse production in 1982-83 to 1990-91. After then, due to scarcity of foodgrain, rice production was increasing and pulse production was decreasing. Production of fruits remained almost same over the years but production of

vegetables and potatoes increased relatively at a higher rate over the years. Among the other crops oil seeds production was increasing over the years. However, potatoes were the other major crops with a substantial production increase. At present, some experts believe that potato is the third crop in Bangladesh. Fiber production has been erratic since 1972-1992, primarily because of the fluctuation in world prices and the ease with which substitution between jute and aus rice can occur. Farmers traditionally alter their production between those crops depending on relative profitability. This continued a production decline that began it! 1979. If we consider the growth rate of fiber production then we can say that the production of fiber is decreasing continuously.

It is observed that the yield of rice shows a rising trend over the years 1972-73 to 1998-99. The yield of wheat was 758 kg/ha in the year 1972-73. After 25 years, there was 185.22 per cent (2162 kg/ha) increase it in the year 1998-99. Minor cereals, total cereals, pulses, oilseeds, spices and condiments, vegetables, tobacco, fiber and potatoes increased by 11.37, 89.17, 5.56, 79.89, 14.93, 4.47, 51.21, 33.23, 8.1 per cent respectively from 1972-73 to 199899. The yield of rice increased by 87.69 per cent within this period. Area irrigated for most of the food crops such as rice, wheat, potatoes, oil seeds and vegetables are increasing during the last three decades in Bangladesh. Trends in land productivity, irrigation coverage and chemical fertilizer uses in Bangladesh are estimated also and are shown in the Table 4. Both the positive and negative increment of output and irrigation over previous years were observed. Negative productivity of fertilizer and irrigation is common in the year 1973-74, 1979-80, 1988-89 and 1994-85. It means that land productivity is decreased over the previous years due to relative increment of output for using fertilizer and irrigation. So land productivity is fluctuated by using of fertilizer and irrigation to the land. In order to assess the trends in the contribution of growth augmenting inputs such as chemical fertilizer and irrigation to growth of rice production, the productivity indicators have been updated. The productivity indicators were first estimated from the annual increments in the land productivity in relation to early changes in the use of chemical fertilizer per unit of net cultivated land and in the proportion of irrigated land out of total net cultivated land. The productivity estimates, which can be taken, only as rough indicators of the impact of increased intensity of modern input use on land productivity are presented in Table 5. The productivity indicators provide a rather disconcerting picture about the factor productivity in Bangladesh agriculture.

Table 5. Trends in land productivity, irrigation coverage and chemical fertilizer uses in Bangladesh

Year	Gross output of rice per NCA (M. Ton/ha	Fertilizer useper NCA (kg./ha)	Area under irrigation as % of NCA	Increment of output over previous year	Increment of irrigation over previous year (B)	Increment of irrigation over previous year (C)	Productivity	
							Fertilizer (A)/(B)	Irrigation (A)/(C)x 100
1972-73	1.05	46.26	46.00	-	-	-	-	-
1973-74	1.21	45.47	36.44	0.16	+0.79	-9.56	-0.2025	1.67
1974-75	1.15	32.59	42.86	-0.06	-12.88	6.42	0.0047	0.93
1975-76	1.24	53.13	40.15	0.09	20.54	-2.71	0.004	3.32
1976-77	1.19	61.55	36.29	-0.05	8.42	-3.83	-0.0059	1.31
1977-78	1.29	86.52	42.86	0.10	24.97	6.57	0.0040	1.52
1978-79	1.27	83.92	43.50	-0.02	-2.6	0.64	0.0077	3.13
1979-80	1.25	94.83	45.83	-0.02	10.19	2.33	-0.0018	0.86
1980-81	1.35	98.94	47.30	0.10	4.11	1.47	0.0243	6.80
1981-82	1.30	92.86	49.67	-0.05	-6.08	2.37	0.0082	2.11
1982-83	1.34	101.21	53.03	0.04	8.36	3.36	0.0048	1.19
1983-84	1.38	117.40	54.84	0.04	16.19	1.81	0.0025	2.21
1984-85	1.43	144.28	59.26	0.05	26.88	4.42	0.0019	1.13
1985-86	1.45	129.36	59.13	0.02	-14.92	-0.13	-0.0013	15.38
1986-87	1.45	148.70	61.37	0.00	19.34	2.24	0	0
1987-88	1.55	181.66	70.01	0.10	32.96	8.64	0.0030	1.16
1988-89	1.52	201.78	82.96	-0.03	20.12	12.95	-0.0015	0.23
1989-90	1.70	235.74	86.89	0.18	33.96	3.93	0.0053	4.58
1990-91	1.71	244.14	91.50	0.01	8.41	4.61	0.0019	0.22
1991-92	1.78	270.80	99.99	0.07	26.66	8.49	0.0026	0.82
1992-93	1.80	279.96	105.14	0.02	9.16	5.15	0.0022	0.39
1993-94	1.81	270.28	105.19	0.01	-9.69	0.05	-0.0010	20.00
1994-95	1.70	326.16	109.41	-0.11	55.88	4.22	-0.0020	2.61
1995-96	1.78	365.76	112.50	0.08	39.60	3.09	0.0020	2.59
1996-97	1.86	367.26	116.21	0.08	1.50	3.71	0.0533	2.16
1997-98	1.84	337.45	119.20	-0.02	-29.81	2.99	0.0007	0.67

Analyzing the selected major crops shows an interesting variation in the relationship of acreage and yield relative to production improvements for the period. The basic data for the ten crops are shown in Table 6. These crops represented 95 per cent of the cropped area for Bangladesh in both 1972-73 and 1998-99. Rice production increased over nine million metric tons (97.2 per cent increase) between 1972-73 and 1998-99. Of the total increase, 11.5 per cent was associated with additional land, 100.3 per cent with improved yields. Approximately, 64.4 per cent of the increase for wheat and 14.6 per cent for the minor cereals were related to yield improvements. Production of pulses increased by 248 thousand metric tons for the period, associated mostly with expanding acreage through multiple cropping (86.6 per cent). On the other hand, fiber production decreased by 30 per cent (365 thousand metric tons), but 136.5 per cent of the change was associated with a decline in acreage, which offset the limited positive impact of improved yields (45.3 per cent). Interestingly, the reverse was true for tobacco where 32.4 per cent of the output increase was related to yield improvements

those were partially offset by 36.3 per cent decline in acreage. Table 7 interpret larger acreage change (increase) is observed for minor cereals, pulses, sugar crops and potatoes. But tobacco, fibers and spices show decrease acreage. Of the total increase, higher percentage associated with improved yield was for rice, spices and tobacco. In no cases the effect of changes in cropping or the interaction of yield with cropping pattern prove to be of major importance. The relationship between acreage and production for the major crops was most noticeable for potatoes and fibers. Potato production increased by 39.8 percent (236 thousand tons), and 75.9 percent of the change was related to shifts in acreage. Jute production, on the other hand, decreased by 23.4 per cent (261 thousand tons), but 130.7 per cent of the change was associated with a decline in acreage, which offset the limited positive impact of improved yields (40 per cent).

Table 6. Average production, acreage and yield for major crops in Bangladesh, 1972-73 and 1998-99

Crops	1972-73			1998-99		
	Acreage ('000' ha) A_0	Yield Tons/ha Y_0	Production ('000' m tons) P_0	Acreage ('000' ha) A_0	Yield Tons/ha Y_0	Production ('000' m tons) P_0
Rice	9629	1.048	10091	10115	1.967	19896
Wheat	120	0.758	91	882	2.162	1908
Minor Cereals	30	0.633	19	88	0.705	62
Pulses	314	0.720	226	547	0.761	414
Oil Seeds	301	0.761	229	511	1.369	700
Spices	153	2.137	327	149	2.456	366
Sugar crops	128	42.211	5403	191	38.084	7274
Tobacco	91	0.703	64	80	1.063	85
Fibers	905	1.345	1217	515	1.654	852
Potatoes	143	10.140	1450	287	10.958	3145
Total Land	11,814	-	-	13365	-	-

Table 7. Sources of changes in production for major crops 1972-73 and 1998-99

Crop	Change in output for the period	Source of change				Total
		Acreage	Yield	Cropping Pattern	Interaction	
Rice	97.2	11.5	100.3	-6.3	-5.5	100
Wheat	9563.2	29.7	64.4	2.1	3.8	100
Minor Cereals	226.3	85.0	14.6	0.4	*	100
Pulses	83.2	86.6	11.7	1.6	0.1	100
Oil Seeds	205.7	32.9	65.1	1.1	0.9	100
Spices	11.9	-20.3	122.1	-1.6	-0.2	100
Sugar crops	34.6	140.8	942.0	1.3	-0.1	100
Tobacco	32.8	-36.3	137.2	-0.6	-0.3	100
Fibers	-30.0	-136.5	45.3	-7.2	-1.6	-100
Potatoes	116.9	84.6	13.7	1.6	0.1	100

* Less than 0.1 percent

Growth Rate and Stability of Crop Production

The compound growth rates and instability index of different crop area, production and yield for 27 years in different periods are presented in Table 8. Estimated compound growth rate of crop implies that areas of wheat, pulses, oilseeds, vegetables and potatoes increased in all the periods. The area of tobacco, fiber crops and spices were decreased whereas the area of minor cereals decreased during the seventies and nineties but increased in eighties. The compound growth rate of rice production and yield were 2.26 and 2.21 per annum respectively during the 27 years period. The results interpret that growth rate of production and productivity is decreasing in each decade. Production and productivity of wheat and potatoes were also higher in last 27 years but their growth was unstable. The long-term growth trends in wheat production have been dramatic.

Comparatively, higher production of minor cereals, pulses and oilseeds were observed but they show very low productivity. The annual growth rate has been sustained generally at significant levels through recent years. The negative growth rate of production and productivity of some crops are shown since 1980-81 to 1989-90, because of natural hazard of production. The annual growth rate of pulse production was 4.6 per cent during 1972-73 to 1998-99 but recent growth rate was negative. Tobacco and fibers show high productivity per year per hectare but their production growth rate was low due to reduction of their area cultivated. During the period 1972-73 to 1979-80, the increase in the production of wheat, pulses and sugarcane was mainly due to the increase in area rather than due to increase in yield. The productivity increase in rice, tobacco and fiber crops contributed much more than the increase in area to increased production. During the period 1980-81 to 1989-90, the increase in the production of minor cereals, pulses, oilseeds, sugar crops was mainly due to

Table 8. Compound growth rates and instability indices of the major crop area, production and yield

	1972-73 to 1979-80		1980-81 to 1989-90		1990-91 to 1998-99		1972-73 to 1998-99	
	CGR	I_x	CGR	I_x	CGR	I_x	CGR	I_x
Area								
Rice	0.62**	1.66	-0.06**	1.36	0.19**	158.8	0.08**	2.41
Wheat	18.29	-	0.69*	7.92	4.95**	5.33	0.93*	22.64
Minor cereals	-4.17*	4.03	32.18	-	-2.89**	1.85	7.83	-
Total cereals	0.96**	1.65	0.09*	1.18	0.09**	1.73	0.35**	2.92
Pulses	1.83**	3.82	14.00	-	-2.29*	5.53	4.40**	23.38
Oil seeds	1.71*	5.11	10.06	-	-0.43**	3.23	3.39**	16.21
Spices	0.78**	3.36	-0.21**	2.47	0.08**	1.36	-0.30**	2.51
Sugar crops	1.47*	5.93	2.28**	4.07	0.99**	0.92	1.41**	6.35
Fruits, veget.	1.84**	0.85	2.23**	1.61	1.73**	0.91	1.87**	1.94
Tobacco	0.41	-	0.70**	1.80	-1.10**	2.12	-0.61**	5.68
Fibers	-1.54	-	-0.47	-	-0.56	-	-2.14*	22.36
Potatoes	2.43*	4.88	-0.48*	3.05	0.26**	0.29	0.63**	4.08

Production								
Rice	2.83*	5.08	2.44**	3.12	0.96**	3.96	2.26*	4.45
Wheat	38.40	-	-1.40	-	8.26*	6.13	9.43	-
Minor cereals	-4.20	-	34.58	-	-2.98**	1.56	8.51	-
Total cereals	3.57*	4.77	2.25**	2.74	1.43**	4.04	2.52**	4.61
Pulses	0.44*	4.03	14.68	-	-1.47*	5.97	4.66**	23.20
Oil seeds	3.43	-	8.57	-	3.71	-	4.22**	13.71
Spices	-0.94**	2.61	1.98**	5.13	0.77**	4.34	0.38**	4.34
Sugar crops	2.05	-	0.54**	4.84	-0.60**	2.44	0.92**	2.44
Fruits	-0.18**	1.35	0.32**	2.50	0.03**	1.36	0.41**	1.36
Vegetables	1.39*	5.46	-5.24	-	3.28**	7.32	-0.13**	2.42
Tobacco	3.58	-	-1.52**	3.90	1.10**	3.56	0.53**	3.56
Fibers	1.47	-	0.37	-	-1.17	-	-0.21**	10.80
Potatoes	2.66*	5.36	-1.13**	5.28	4.65*	15.38	1.27**	15.38
Yield								
Rice	2.63*	4.24	2.13**	1.95	1.55**	3.92	2.21*	3.77
Wheat	12.52	-	-0.92	-	2.42*	7.21	2.63**	19.95
Minor cereals	1.01**	4.53	1.57**	6.25	0.25**	2.27	0.46**	5.61
Total cereals	2.72*	4.16	1.98**	1.92	1.64**	3.53	2.19**	3.34
Pulses	-1.36**	2.31	0.55**	2.74	0.83**	0.76	0.25**	4.04
Oil seeds	1.68	-	-1.36**	5.54	4.15**	14.72	0.80**	11.25
Spices	-2.05	-	1.44*	7.98	0.70**	3.20	0.29**	9.70
Sugar crops	0.56**	1.50	-1.77**	1.80	0.24**	2.44	-0.61**	3.52
Tobacco	3.17**	3.72	-0.86**	3.30	2.23**	4.47	1.14**	8.99
Fibers	2.64	-	0.84**	4.50	0.10**	4.23	1.14**	6.67
Potatoes	0.23**	1.34	-0.65**	3.57	18.41	-	2.45*	13.04

CGR= Compound growth rate per annum in percentage and I_x = Instability index
Significant level: * p<.05: ** p<.01.

the increase in area. During the period 1990-91 to 1998-99, the increase in the production of rice, tobacco, oilseeds, potatoes and spices was mainly due to the increase in yields. During the 27 years, the increase in the production of minor cereals, pulses, oilseeds and sugar crops was mainly due to increase in area rather than increase in yield, whereas the increase in the production of rice, wheat, tobacco, fiber crops and potatoes was mainly due to increase in yield. The study by Dhakal (1993) revealed that except the tuber crops, all of other crops exhibited significant positive growth in area and production. Khan (1998) examined the growth rates of area and production of major pulse crops in high, medium and low concentration areas of Bangladesh. The study revealed that the major pulse crops had significant positive growth in area and production.

Table 8 reveals that the instability of the majority of the crop yields was lower than instability in production. The high instability of per hectare yield was due to the fact that the crop was mostly grown under rained condition and in marginal land. Some crops such as wheat, pulses, oilseeds, potatoes and fiber crops showed higher instability due to wide year to year fluctuation in output, yield and area under the crops. Higher instability of output and yield variability of these crops were associated with positive and significant growth rates. Instability index of spice area decreased but that of production increased in the second period

compared to the first period (Table 8). To compare the three periods and overall 27 years period, growth of area and production of total cereals, spices, fruits and vegetables and yield of total cereals and sugar crops were more stable. Unstable higher growth of wheat, pulses, oilseeds and potatoes were observed. The findings by Chowdhury (1996) showed that area and production of non-cereal crops exhibited more fluctuation than cereal crops and has a significant positive growth rate in all crops. According to Sabur and Miah (1996), area under pulses, oilseeds and sweet potato declined whereas that to cereals and potato increased since independence. But this study reveals that the production of growth rate of pulses and oilseeds improved in the recent years.

Table 9 presents the instability measures of total irrigated area and irrigated crop area. Area irrigated by modern method was increased at higher rate, especially, from late nineties whereas area irrigated by traditional method exhibits decreasing trend and consequently area under total irrigation shows rapid increase. Growth rate of irrigated area using modern method was very high during all the periods. The growth rate of irrigated area for rice, vegetables and sugar crops were much higher during the period 1985-86 to 1997-98 than that of the period 1972-73 to 1984-85. The growth rate of irrigated area of wheat, oilseeds and potatoes was very high.

Table 9. Compound growth rate and instability index of irrigated area

	1972-73 to 1984-85		1985-86 to 1997-98		1972-73 to 1997-98	
	CGR	Ix	CGR	Ix	CGR	Ix
Total irrigated area	**3.48****	**8.86**	**4.92****	**7.77**	**-**	**-**
Traditional method	-4.07*	11.14	0.13*	12.45	-3.21**	16.33
Modern method	7.77*	14.30	5.74**	5.29	7.87**	10.54
Crop areas						
Rice	2.27**	9.21	5.42**	6.09	5.05**	11.03
Wheat	30.08	-	2.44*	9.06	10.85	-
Minor cereals	2.36	-	1.39	-	1.10*	26.49
Pulses	2.76	-	-1.60	-	1.75	-
Potatoes	5.19**	7.83	3.62	-	2.70*	14.47
Oilseeds	13.66	-	5.60	-	11.29**	22.27
Vegetables	2.97**	7.14	6.58	-	4.43**	15.53
Sugarcane	1.30	-	4.12	-	2.82**	16.52

CGR= Compound growth rate per annum in percentage and I_x = Instability index
Significant level: * p<.05: ** p<.01.

Regional Variations of Crop Production

A significant difference in agricultural production and productivity is observed when comparisons are made on regional basis. It is observed that a considerable amount of variation in production and productivity exists among the regions. Total cropped area was higher in southwest and northwest regions and lower in southeast region. Percentage share is increasing

in northwest region but decreasing in southwest region. Net cropped area sown is the highest in southwest region and the lowest in southeast region. Intensity of cropping is comparatively higher in southeast and northwest regions. Detailed regional distribution of total cropped area, net-cropped area and cropping intensity of Bangladesh is presented in Table 10.

Table 10. Regional distribution of total area, cropped area and cropping intensity of Bangladesh

	Regions				Total of
Item Year	SE	NE	SW	NW	Bangladesh
Total area ("000' ha)	3442 (23.20)	3679 (24.79)	4272 (28.79)	3446 (23.22)	14839
Net cropped area ('000' ha)					
1993-94	1116 (14.45)	2131 (27.58)	2340 (30.29)	2138 (27.68)	7725
1994-95	1100 (14.21)	2205 (28.48)	2348 (30.32)	2090 (26.99)	7743
1995-96	1128 (14.46)	2218 (28.42)	2323 (29.97)	2134 (27.35)	7803
1996-97	1114 (14.17)	2225 (28.30)	2332 (2967)	2190 (27.86)	7861
1997-98	1122 (14.08)	2243 (28.15)	2351 (29.51)	2252 (28.26)	7968
1998-99	1097 (13.73)	2233 (27.95)	2284 (28.59)	2375 (29.73)	7989
Total cropped area ('000' ha)					
1993-94	2014 (14.94)	3627 (26.90)	3939 (29.22)	3901 (28.94)	13481
1994-95	2006 (14.84)	3728 (27.57)	3964 (29.32)	3823 (28.27)	13521
1995-96	2021 (14.96)	3694 (27.34)	3930 (28.88)	3895 (28.42)	13513
1996-97	2058 (14.92)	3748 (27.17)	3974 (28.81)	4029 (29.20)	13795
1997-98	2070 (14.69)	3814 (27.07)	4041 (28.69)	4162 (29.55)	14087
1998-99	1989 (14.13)	3852 (27.37)	3901 (27.72)	4330 (30.78)	14072
Intensity of cropping					
1993-94	180.47	170.20	168.33	182.46	174.51
1994-95	182.36	169.07	168.82	182.92	174.62
1995-96	179.17	166.55	168.02	182.52	173.18
1996-97	184.74	168.45	171.15	183.97	175.71
1997-98	184.49	170.04	171.88	184.81	176.79
1998-99	181.31	172.50	170.80	182.32	176.14

Figures in the Parentheses are the percentage shares of the regions

Percentage of total cropped area to total geographic area, percentage of irrigated area to total cropped area, cropping intensity and productivity of rice increased tremendously in 1998-99 compared to 1984-85. The average total cropped area as a percentage of total geographic area increased from 99.28 per cent in 1984-85 to 103.42 per cent in 1998-99. The average irrigated area as a percentage of total cropped area increased highly from 15.59 per cent in 1984-85 to 27.40 per cent in 1998-99. The disparity among the districts (as measured by CV) was pronounced in respect of all indicators except "cropping intensity"(Table 11). The indicator 'forest area to total geographic area' is much high in some districts and also nil in other districts and hence CV is very high for this indicator. The disparity in total cropped area, net area sown, irrigated area and productivity of rice were more or less at the same level in both the periods. Significant reduction of disparity among the districts in 1998-99

compared to 1984-85 for the development indicator 'cropping intensity' (CV: 12.6 to 5.4) and 'productivity of wheat' (CV: 34.1 to 25.4). Whereas, significant increase of disparity among the districts for the development indicator percentage of HYVs due to giving more emphasis in some districts. In general, the disparity was declining in case of most of the indicators.

Table 11. Disparities in agricultural indicators

SL	Development Indicators	1984-85			1998-99		
		Mean	S.D.	CV	Mean	S.D.	CV
1	PFA	10.27	21.0	204.1	10.63	20.8	195.8
2	PCA	99.28	32.6	32.8	103.42	35.5	34.3
3	PNA	64.44	18.0	28	58.16	17.4	29.8
4	CI	151.59	19.1	12.6	175.49	9.4	5.4
5	PIC	15.59	7.1	45.7	27.40	11.7	42.8
6	PRR	61.44	11.1	18	77.91	14.4	18.4
7	PRW	75.56	25.8	34.1	77.77	19.7	25.4
8	PAHYV	92.97	19.9	21.4	60.66	20.3	33.5

In the ranking method, Bogra with a total rank of 36 in 1984-85 and 31 in 1998-99 secured the first position (Table 12). This district was on the top pertaining to one indicator (percentage of HYVs) in 1984-85 whereas it was on the top pertaining to three indicators (percentage of total cropped area to total area, percentage of irrigated area to total area and cropping intensity) in 1998-99. This indicates that total cropped area, irrigated area and cropped area sown were increased rapidly in Bogra district. Mymensingh was on the second, third, fourth, fifth and sixth positions pertaining of the indicators cropping intensity, percentage of HYVs, total cropped area, productivity of wheat and productivity of rice respectively in 1984-85 and hence with a total rank of 45 shared second position. This district has slipped to 9th position with a total rank of 75 in 1998-99. Jesore has occupied the second position with a total rank of 45 in 1998-99. Comilla has occupied third position in 1984-85 and has felt in tenth position in 1998-99. Jamalpur and Tangail were in good positions in 1984-85 and a little down in position in 1998-99. Index based on the eight agricultural development indicators have been computed for the period 1984-85 and 1998-99 for each district and presented in Table 12. The table represents the value of index for each district with the rank allotted on the basis of these indices. It may be observed from the table that out of 20 former districts of Bangladesh Chittagong Hill Tracts was on the top position and Khulna was on the second position for both in 1984-85 and 1998-99. Chittagong occupied the third position in 1984-85 but declined to the fifth position in 1998-99. Like Chittagong Hill Tracts and Khulna, some other districts (Jamalpur, Tangail and Pabna) show same index values in both the periods.

Table 12. Rank and index total for agricultural indicators and the position of districts

Districts	Total Ranks				Total Indices			
	1984-85		1998-99		1984-85		1998-99	
	Rank	Position	Rank	Position	Index	Position	Index	Position
Chittag. Hilltract	109	16	98	13	157	1	160	1
Chittagong	68	6	95	12	126	3	111	5
Comilla	55	3	76	9	101	9	99	10
Noakhali	84	10	113	15	92	13	90	12
Sylhet	98	13	117	16	89	15	83	13
Dhaka	82	9	93	11	96	12	95	11
Faridpur	101	15	118	17	80	18	64	15
Jamalpur	55	3	65	6	103	7	105	7
Mymensingh	45	2	75	8	106	6	99	10
Tangail	60	4	69	7	116	4	114	4
Barisal	100	14	128	19	78	19	62	16
Jessore	87	11	45	2	90	14	105	7
Khulna	71		111	14	131	2	121	2
Kustia	70	8	52	3	103	8	106	6
Patuakhali	129	17	122	18	51	20	66	14
Bogra	36	1	31	1	109	5	117	3
Dinajpur	87	11	69	7	87	17	100	9
Pabna	66	5	78	10	97	11	95	11
Rajshahi	91	12	57	5	88	16	104	8
Rangpur	69	7	54		98	10	104	8

IV. CONCLUSIONS

The yields of rice, wheat, oilseeds and potatoes irrespective of their increasing trends are still far below the level needed to meet Bangladesh's growing food needs. To increase more yields farmers should be motivated to give more emphasis on irrigation, investments in HYVs, fertilizer and improved cultural practices. To increase agricultural production the Government should actively take initiative for development of irrigation, flood control and drainage, agricultural research and extension, and development of HYVs of non-cereal crops.It is clear that for most of the major crops, yield increases have been relatively more important, regardless of the level of increased output, which reflects the adoption of new technologies and inputs that made it possible to intensify land use through multiple-cropping.

Care should be taken for improving yield levels of usual slow growth crops like minor cereals, pulses and oilseeds. This is to accelerate the trends of crop diversification. The fluctuation in yield is the major cause for the fluctuation in the production and hence the fluctuations in yield have to be controlled to bring in stability in the production. This would mean concerted research efforts in developing new varieties of crops whose yield potential is stable across different agro-climatic regions.

Region-wise analysis shows that contribution of area expansion to total growth of output and the improvement in yield rate to the increase of total growth of output in all the regions except the southwest region. Significant increase of disparity among the districts for the development indicator percentage of HYVs due to giving more emphasis on some districts in general, the disparity was declining in case of most of the indicators. Most of the districts show better position in 1998-99 compared to 1984-85. Bogra, Jesore, Mymensingh and Commila districts show better positions using ranking methods whereas Chittagong, Chittagong Hill Tracts and Khulna show better positions using indexing method.

Development is a multidimensional process and its impact cannot be measured completely by single indicator. In the present analysis regional disparities of agricultural sector based on eight indicators only, were studied and significant disparities are found between the districts. The districts, which are low developed, require improvements of various dimensions of different indicators for enhancing their level of development. So, a sustainable policy is needed to balance the inter-districts inequalities in the level of development and to overall growth of agricultural sector. A sustainable research work on inter-district differentials of income, agricultural variations using development indicators and socioeconomic infrastructure will be a useful achievement for the regional development of the country.

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APPENDIX I

Effects of Technical Change

The algebraic formulas below are an expression of this basic logic, with the addition of calculations for differences in production associated with changes in cropping patterns and the interaction of cropping pattern and yields. The components which explain the changes in output between tow periods 1972-73 and 1998-99 for an individual crop can be broken down algebraically as follows.

Change in total output: $P_t - P_o =$

Change in acreage: $Y_o[A_t(1+C_o-C_t)-A_o]+$

Change in yield: $[A_t(1+C_o-C_t)(Y_t-Y_o)]+$

Change in cropping pattern: $[A_t Y_o(C_t-C_o)]+$

Change in interaction of cropping pattern and yield: $[A_t(Y_t-Y_o)(C_t-C_o)]$

Where,

P_o = Crop output in 1972-73

P_t = Crop output in 1998-99

A_o = Crop area in 1972-73
A_t = Crop area in 1998-99
C_o = The proportion of total cropped area planted to an individual crop in 1972-73
C_t = The proportion of total cropped area planted to an individual crop in 1998-99
Y_o = The crop yield in 1972-73
Y_t = The crop yield in 1998-99

With all data as averages for the two years indicated.

Growth Rate

The compound growth rates were worked out by an exponential function of the form

$$LnY_t = Lna + tLnb + U_t$$

Where Y_t is the value of area / production / yield at time t.

a = constant
b = regression coefficient
t = time variable in years 1, 2, ..., n.
U = disturbance term.

Compound growth rate (r) was given by

$r = \text{Anti-Ln (b)} - 1 = (e^b - 1) \times 100$

And expressed as per cent per annum. The compound growth rates were tested for their significance by the student t statistic given by

$$t = r / \text{S. E. (r)}$$

Where, $\text{S. E. (r)} = (100b / \text{Log } e_{10}) \times \text{S.E.(b)}$

Instability Index

The instability index was measured whenever the compound growth rate was found significant. The index of instability was constructed as follows:

$$I = (CV) \times \sqrt{1 - R^2}$$

$$\text{Where, } CV = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

$I\text{-}R^2$ is the unexplained portion of the variation in the trend equation

Projection

At the rates of growth, the total projected production of various agricultural productions in the year 2005-06 has been estimated on the basis of trends as follows:

$$X_t = X_o (1 + r/100)^n$$

Where X_t = Production of X commodity in t^{th} period
X_o = Production of X commodity in base period
r = Compound growth rate on the basis of time series data.
n = Number of years considered for projection