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ANALYSIS OF TOTAL FACTOR PRODUCTIVITY OF WHEAT IN BANGLADESH

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Abstract

The study dealt with the total wheat scenario in terms of productivity growth in Bangladesh covering the period from 1980 to 2006. The 26 years of wheat production period was divided iaio three consecutive sub periods: period I (1980 to 1990), period II (1991 to 2000) and period III (2001 to 2006). Technological breakthrough was started from the mid of the 1" period and continued up to the end of the 2°d period. The study revealed that the growth rate of inputs used was higher in the 2nd period than in the 1S` period. The growth rate of output price was always lower than that of input prices. In spite of the lowest partial factor productivity indices of all the input, the total factor productivity indices were highest in the 2nd period. The 28 years' (1972-73 to 1999-00) mean rainfall and temperature did not favour the farmers to produce more wheat. In aggregate sense, the wheat production in the 2"d period was the most cost effective. The growth rate of yield was found to be 0.2 percent during the study period. Of the period, only 2nd period was considered as the golden revolutionary period in the history of wheat in Bangladesh since 1980. Technological change in wheat production in the golden revolutionary period has relatively benefited consumers more than producers. Research, mechanization and market are the most important sources of growth in total factor productivity. The extent of annual fluctuation of wheat productivity will have to be minimized by more efficient use of inputs.

I. INTRODUCTION

Wheat is the second most important staple food crop in Bangladesh after rice. Its importance as a food and nutrition security crop has increased since independence. Per capita intake of wheat stands at 28-30 gm/day, indicating its approximate demand at 4 million tons per annum (Anon., 2004). To meet the increasing consumer's demand, the country has to import on an average 1.4 million tons of wheat every year by putting excessive pressure on available foreign exchange reserves (BM 2005). In addition , consumption of wheat is increasing due to rapid urbanization and industrialization of the country and the consequent increase in the use of numerous bakery products like breads, rolls, crackers, cookies, biscuits, cakes, waffles, noodles, puddings, pizza, bulgur, rolled flakes, many hot and ready-to-eat breakfast foods etc (Mian et al. 2001).

The farmer used inputs like labour (both human and animal labour), seed, fertilizers, manures, pesticides, irrigation in the production process of wheat. The productivity of all these inputs mainly depends on the technical change meaning that the price related advantages forced the

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farmers to take appropriate decision with the available state of technology. Given the existing technology, the farmers always try to maximize profit through readjusting enterprise combination continuously. As a result, the productivity of inputs sometime moves upward and sometime goes downward for a specific enterprise like wheat. Consequently, the inputs as well as output indices were going to higher and also lower for wheat during study period. Under such a situation, a thorough investigation is needed to find out the related reasons behind it.

Formal research on wheat was initiated in the late seventies. From the beginning of the period 1980 to 1990, wheat area and production started to increase steadily till at the end of the period 1991 to 2000. A downward trend in both area and production of wheat from 2001 onward was observed. Therefore, the scenario of wheat in Bangladesh needs to be analyzed for about three consecutive decades from year 1980 to 2006. In order to do so, total factor productivity index analysis was undertaken with the following objectives a) to estimate the inputs used in wheat production, b) to construct the partial as well as total factor productivity indices and c) to provide a policy guideline for scientists, extension personnel and policy makers.

II. Method of Measurement of Total Factor Productivity Index

The pioneering work of Solow (1957) in devising a method for measuring technological progress led the way to the estimation of total factor productivity. Solow defined total factor productivity (TFP) as follows:

qp,=q -a, (L, - (1-at)K

where, (p_t = growth rate of productivity as the residual after deducting the contributions of labour and capital, q, = growth rate in value of output, a, = share of labour, L, = growth in labour cost, (1, - a,) = share of capital in total revenue, K= growth in capital cost and a_t and (1_t - a) = the weights derived from Cobb-Douglas production function.

These last two variables are the basis of the so-called Divisia index. The Divisia index is a weighted sum of the growth rates, where the weights represent the components' share in total revenue. Use of this procedure implies perfect competition and constant returns to scale. Subsequently, the formulation was modified by Tornqvist (Christensen 1975 and Diewert 1976). The modification consists in using as weights the average of the period (t-1) and t. The Tornqvist-Theil index noted below was used by Rosegrant and Evenson (1992 and 1993) in their measurement of total factor productivity in Pakistan and Indian agriculture. A comprehensive review of various methods for computing the total factor productivity index and their mathematical details are found in Grosskopf (1993).

In short, the productivity indicates a bundle of output produced from a bundle of unit of inputs while the total factor productivity measures the rate of change in the cost of producing output relative to the rate of change in revenue. The salient feature of the model was that, cost of production was weighted average of the cost of different factors of production, using the share of factors as weights. These techniques, popularly known as the Tornqvist-Theil index (Alston, et al. 1995), are as follows:

Total Output Index (TQI)

$$TQI_t / TQI_{t-1} = \Pi_j (Q_{j,t} / Q_{j,t-1})^{(Rjt+Rjt-1)\,½} \quad (1)$$

Total Input Index (TII)

$$TII_t / TII_{t-1} = \Pi_i (X_{i,t} / X_{i,t-1})^{(Sit + Sit-1)½} \quad (2)$$

Total Factor Productivity Index (TFPI)

$$TFPI_t = (TQI_t/TII_t)*100 \quad (3)$$

where, R_{jt} is the share of wheat output j in total revenue, Q_{jt} is wheat output j, S_{jt} is the share of input i in total cost, X_{it} is input i. By specifying TOI_{t-1} and, TII_{t-1} equal to 100 in the initial year 1980, the above three equations provide the total output, total input and total factor productivity indices for the specified period t.

The study analyzed the whole scenario of wheat production in Bangladesh covering the period from 1980 to 2006. The 26 years of wheat production was divided into three consecutive sub periods: the 1st period was 1980 to 1990, the 2nd period was 1991 to 2000 and the 3rd one comprised the period 2001 to 2006. The year 1980 was considered as the base for comparing the indices of subsequent years. All the inputs and output were computed based on the current prices. In the process of analyses we have lost one year because of the mathematical formulation for input, output and also the total factor productivity indices.

The next step was to aggregate all the inputs in value term using equation 2. It required multiplying quantity of input by its price. It is important to note that both the physical and monetary values on inputs as well as output using equations 1 and 2 were needed to estimate the total factor productivity by applying equation 3.

Data Sources and Estimation

To construct the total factor productivity index, a rigorous attempt was needed for collecting the time series data on both inputs and outputs. It is very much difficult and sometime impossible to gather data on individual inputs used in any individual crop enterprise. The time series data of individual inputs used for wheat was not an exceptional one. Data on individual inputs were collected from various issues of BBS, BARI annual report, Wheat Research Centre (WRC) report and also from various sources of published materials, books, journals etc. Some missing data on inputs were derived by using recognized statistical techniques of interpolation and extrapolation.

The data on production and area were obtained from various issues of the Bangladesh Bureau of Statistics (BBS). The price data on various inputs were also collected from Bangladesh Bureau of Statistics and Directorate of Agricultural Marketing (DAM). Using all these available data, the time series data on cost and return for wheat were estimated and used in the analysis.

III. RESULTS AND DISCUSSION

Growth Rates of Area, Production and Yield

The 1[5`] and 2[nd] periods of wheat scenario experienced the positive growth rate in area while it was found negative in the 3[rd] period. The annual growth rate of wheat area for the whole period was found only 0.81 percent. In the production, the almost similar trend was found except for the 1[5`] period. On the other hand, annual growth rate of yield was found positive except in the 1[**S1**] period. As a whole, a substantial change was found in both area and production but not in yield (Appendix-I). The annual growth rate of yield for the whole period was found only 0.2 percent. Of the period, the [2°d] period i.e. from 1991 to 2000 was considered as the golden revolutionary period in the wheat history of Bangladesh (Table 1).

Table 1. Annual growth rates of area, production and yield of wheat over the period from 1980 to 2006

Items	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Area (ha)	1.5* (1.6)	4.6*** (8.0)	-9.8*** (7.9)	0.8** (2.0)
Production (ton)	-1.4 ns (0.9)	7.6*** (11.5)	-8.8*** (6.9)	1.5* (1.7)
Yield (ton/ha)	-2.9* (1.9)	3.0*** (8.8)	1.2** (2.9)	0.2*** (4.5)

Figures within brackets are t value, '***', '**' and '*' indicate 1%, 5% and 10% level of significant and ns = not significant.

Inputs used and Output obtained from Wheat and Growth Rates

Table 2 shows the period-wise average inputs used for and output obtained from wheat production. Thee wheat farmers of Bangladesh did not use the recommended fertilizer dose e.g. 178, 159, 40 and 95 kg's of Urea, TSP, MP and Gypsum in any three periods respectively (Anon., 2005). However, very much similar trend was found in two consecutive sub-periods i.e. [2°d] and 3`[d].The lowest amount of inputs was used in the 1[s1] period. This was only due to fact that the technological breakthrough was started from the mid of the 1[51] period (AppendixII). As regards the growth rates of different inputs used for wheat production, the trend of all parameter were found much higher in the 2n[d] period than that of 1[51] period. On the other hand, all the growth rates of inputs were found to be negative in the 3`[d] period. This could be attributed to the fact that both the area and production of wheat started decreasing drastically from the year 2000 due to the effect of rising temperature as well as unusual rainfall in both flowering and grain filling stage of wheat i.e. from the month of January to March (AppendixVII).

Table 2. Period-wise average inputs used in wheat production in Bangladesh (Per hectare)

Inputs and output	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Human labour (man-days)	109.3	122.1	124.0	117.6
Draft power (pair-days)	25.2	30.9	30.1	28.5
Seed (kg)	149.0	162.2	155.3	155.5
Manure (kg)	2058.1	3099.8	3236.8	2730.8
Urea (kg)	86.0	90.0	96.0	91.8
TSP (kg)	74.8	79.4	78.3	77.4
MP & Gypsum (kg)	20.0	71.2	65.2	50.1
Pesticides (kg)	0.1	0.3	0.8	0.3
Irrigation (hrs.)	27.7	31.6	30.9	29.9
Rent (kg)	464.3	476.1	502.1	477.6
Wheat (ton)	1.89	1.98	2.00	1.95
Straw (ton)	3.42	3.35	3.51	3.41

Table 3. Annual growth rates of inputs used in wheat production in different period from 1980 to 2006

Inputs	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Human labour (man-days)	2.1 ns (1.5)	5.1*** (8.2)	-10.4*** (8.8)	-1.5*** (3.4)
Draft power (pair-days)	1.7 ns (1.0)	6.5*** (7.2)	-13.7*** (9.9)	1.9*** (3.7)
Seed	2.2** (2.6)	5.2*** (9.3)	-10.8*** (9.2)	1.1*** (2.5)
Manure	2.9 ns (1.4)	6.2ns (1.8)	-9.4*** (4.6)	3.4*** (4.7)
Urea	0.3 ns (0.2)	5.4*** (5.9)	-12.0*** (6.1)	0.9** (2.1)
TSP	1.1 ns (1.2)	5.7*** 6.9)	-10.4*** (5.8)	1.1*** (2.5)
MP & Gypsum	0.9 ns (0.8)	6.7*** (7.4)	-10.6*** (7.8)	7.4*** (6.7)
Pesticides	-20.1** (2.4)	29.0*** (13.2)	-2.5 ns (1.2)	13.1*** (6.0)
Irrigation	1.4 ns (1.2)	5.3*** (3.4)	-11.1*** (6.1)	1.4*** (2.8)
Rent	1.9 ns (1.3)	5.1*** (6.9)	-10.3*** (7.6)	1.2*** (2.8)

Figures within brackets are t value, '***', '**' and '*' indicate 1%, 5% and 10% level of significant and ns = not significant

Growth Rates of Input and Output Prices

The growth parameters of prices for human labour, draft power, seed, manures and urea were found very much lower in the 2nd period compare to the 3rd while the growth rates of the rest input prices were found to be higher in the 2nd period than that of 3rd period (Appendix-III). The overall growth rates of output price in each of the sub-period were found to be much lower than the growth rates of input prices (Table 4). It means that the profit of the wheat farmers decreases day by day and negative sometimes (Appendix-IV and V). Moreover, the mean of 28 years' (1972-73 to 1999-00) rainfall and total rainfall and the mean temperature from November to March were 24.79mm, 123.93mm and 20.32^{0}C respectively, which did not encourage the farmers to produce wheat with intensive care (Appendix-VII).

The wheat growing season is from November to March. The total water requirement for wheat ranges from 250 mm to 300 mm (Anon., 2005) while the total average rainfall is 123 mm which was unusually occurred during the period from January to March. It is harmful for wheat production. On the other hand, the suitable temperature is 13-25^{0}C at grain filling stage (Anon., 2005). At flowering stage the required optimum temperature is below 25-26^{0}C. If it is more than that the pollen will not viable to produce grain resulted in the sterile spike consequently yield was drastically reduced (Ahmed et al.1996)

Table 4. Annual growth rates of price of inputs used and output obtained from wheat production from 1980 to 2006

Inputs and output	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Human labour (man-days)	10.0*** (7.6)	5.2*** (8.9)	9.0*** (4.0)	6.0*** (18.0)
Draft power (pair-days)	10.3*** (6.1)	4.5*** (8.7)	11.0*** (6.9)	5.5*** (14.6)
Seed	2.7*** (7.1)	5.1** (2.5)	6.3*** (4.3)	4.5*** (11.1)
Manure	3.6ns (1.4)	6.18*** (3.9)	6.4*** (3.4)	5.3*** (13.1)
Urea	5.5*** (4.1)	1.18*** (4.9)	2.2*** (7.7)	2.5*** (9.8)
TSP	8.2*** (8.8)	9.7*** (8.1)	4.0*** (4.0)	7.2*** (16.2)
MP & Gypsum	8.3*** (4.7)	6.2*** (5.3)	1.1*** (7.4)	6.5*** (13.2)
Pesticides	6.0*** (6.1)	7.6*** (11.9)	3.4*** (5.5)	6.3*** (33.8)
Irrigation	8.0*** (4.2)	3.1*** (4.1)	6.3*** (3.5)	5.8*** (16.1)
Rent	8.3*** (5.1)	10.7*** (4.9)	5.7*** (4.3)	5.8*** (12.1)
Wheat	6.4*** (6.3)	5.5*** (3.8)	4.6*** (6.5)	4.5*** (15.9)
Straw	1.7ns (1.4)	3.8*** (4.0)	5.1*** (3.4)	3.2*** (13.5)

Figures within brackets are t value, '***', '**' and '*' indicate 1%, 5% and 10% level of significant and ns = not significant

Partial Factor Productivity Indices and Growth Rates

The period-wise average partial factor productivity indices (PFPI) of individual input indices are presented in Table 5. In the 1st period, all the input indices were higher than that of 2nd period. It means that the wheat production was less cost effective in the 1st period compare to the 2nd period. It was further confirmed with the growth rates presented in Table 6 and input prices growth rates in Table 4. All individual input indices were found to be the highest in the 3rd period.

Table 5. Period-wise average partial factor productivity indices of different inputs used in wheat production in Bangladesh

Inputs	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Human labour (man-days)	95.3	79.5	113.9	93.5
Draft power (pair-days)	93.5	78.3	114.8	92.5
Seed	93.3	78.2	114.9	92.4
Manure	92.0	77.4	114.5	91.5
Urea	93.4	78.4	116.5	93.0
TSP	92.6	77.7	115.0	92.0
MP & Gypsum	92.7	77.9	115.6	92.3
Pesticides	92.5	77.7	115.5	92.1
Irrigation	93.5	78.4	116.2	92.9
Rent	96.3	81.4	118.4	95.7

Table 6. Annual growth rates of partial factor productivity indices of different inputs used in wheat production in Bangladesh from 1980 to 2006

Inputs	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Human labour (man-days)	1.7 ns (0.9)	1.0 ns (0.9)	7.1** (3.3)	0.7 ns (1.4)
Draft power (pair-days)	1.7 ns (0.8)	1.1 ns (0.9)	10.2** (4.3)	0.87 ns (1.5)
Seed	1.6 ns (0.8)	1.1 ns (0.8)	10.0*** (4.1)	0.8 ns (1.6)
Manure	1.6 ns (0.8)	1.1 ns (0.8)	10.1*** (4.7)	0.9 ns (1.6)
Urea	1.6 ns (0.8)	1.2 ns (0.8)	10.1*** (4.8)	0.9 ns (1.6)
TSP	1.6 ns (0.8)	1.1 ns (0.8)	10.0*** (4.7)	0.9 ns (1.6)
MP & Gypsum	1.6 ns (0.8)	1.1 ns (0.8)	10.1*** (4.8)	0.9 ns (1.6)
Pesticides	1.6 ns (0.8)	1.2 ns (0.9)	10.1*** (5.0)	0.9 ns (1.6)
Irrigation	1.6 ns (0.8)	1.1 ns (0.8)	10.4*** (5.0)	0.9 ns (1.6)
Rent	1.9 ns (1.0)	1.2 ns (0.9)	9.8** (4.2)	0.9* (1.6)

Figures within brackets are t value, '***', '**' and '*' indicate 1%, 5% and 10% level of significant and ns = not significant

Input, Output, and Total Factor Productivity Indices and Growth Rates

Table 7 shows aggregate output indices (QI), aggregate input indices (XI), total factor productivity index (TFPI), total cost (TC) and gross return (GR). It can be found that the parameters of QI, XI and TFPI were the highest in the 2nd period. It means that in aggregate sense the wheat production was the most cost effective during the 2nd period (Table 7 and 9). On an average, total cost (TC) and gross return (GR) disappointed the farmers, researchers, policy makers and extension personnel to a greater extent. These arguments were further confirmed with the growth rates of QI, XI and TFPI indices respectively. Almost all the growth rates of all indices were found negative (Table 8).

Table 7. Period-wise average of XI, QI, TFPI indices, TC and GR

Indicators	Period of time			
	I 1980-90	II 1991-00	III 2001-06	Overall 1980-06
Aggregate input indices (XI)	112.0	119.9	91.8	110.3
Aggregate output indices (QI)	111.4	129.9	88.4	113.3
TFPI indices	100.3	108.9	96.2	102.8
Total cost (million Tk)	4870.8	11165.1	14593.9	9535.5
Gross return (million Tk)	5169.7	11178.8	12679.9	9214.0

Authors' own estimation

Table 8. Annual growth rates of output, inputs and TFPI indices of wheat production over different periods from 1980 to 2006

Indicators	Period of time			
	I 1980-90	II 1990-00	III 2001-06	Overall 1980-06
Aggregate input indices (XI)	2.1 ns (1.2)	0.4 ns (0.3)	-2.9 ns (1.1)	-0.6 ns (1.4)
Aggregate output indices (QI)	-1.6 ns (0.8)	-1.2 ns (0.8)	-10.18*** (4.9)	-0.9 ns (1.6)
TFPI indices	-3.7** (2.6)	-1.6 ns (1.5)	-7.2 ns (2.1)	-0.3 ns (0.7)
Total cost (million Tk)	10.3*** (8.5)	10.3*** (10.8)	-3.6 ns (1.2)	6.9*** (16.9)
Gross return (million Tk)	4.6*** (3.0)	13.1*** (7.5)	-11.1*** (6.3)	5.5*** (8.1)

Figures within brackets are t value, '***' and '**' indicate 1% and 5% level of significant and ns = not significant

Table 9. Annual indices of total input, total output and total factor productivity of wheat over the period from 1981-82 to 2005-06

Period of time	Year	Aggregate output indices (QI)	Aggregate input indices (XI)	TFPI Indices
1st period	1981-82	100.00	100.00	100.00
	1982-83	113.24	90.34	125.35
	1983-84	141.55	109.27	129.55
	1984-85	151.12	152.27	99.24
	1985-86	97.26	107.04	90.86
	1986-87	84.23	95.22	88.46
	1987-88	113.68	120.71	94.18
	1988-89	105.88	104.40	101.42
	1989-90	95.99	129.58	74.08
2nd period	1990-91	111.04	125.80	88.26
	1991-92	135.89	98.32	138.21
	1992-93	129.47	113.01	114.56
	1993-94	119.47	113.74	105.04
	1994-95	122.37	117.04	104.55
	1995-96	136.82	133.53	102.46
	1996-97	132.00	131.64	100.28
	1997-98	148.86	124.97	119.11
	1998-99	148.32	128.00	115.88
	1999-00	115.35	113.87	101.30
3rd Period	2000-01	99.11	96.70	102.49
	2001-02	98.66	99.56	99.09
	2002-03	101.81	96.57	105.43
	2003-04	87.83	81.37	107.95
		73.20	85.05	86.07
	2005-06	69.92	91.62	76.31
Average		113.32	110.39	102.81

Authors' own estimation

IV. SUMMARY & CONCLUSIONS

The change in yield is a sufficient indicator of productivity. The land productivity can be improved by costly investments that may not fully compensate for the increase in yield. The total factor productivity is also a necessary and sufficient indicator for changes in productivity. But, the present total factor productivity indices of wheat were found uneven but the rate was very slow and not satisfactory. This finding was further confirmed by the partial factor productivity indices. All of these factor productivity indices were not encouraging. On an average, the technological change in wheat production during the past period was not cost effective for the farmers.

Results of the study imply that it is indispensable for the scientists to develop heat and rainfall tolerant high yielding new varieties to regain the previous record. The government should give more emphasis to allocate sufficient fund for further development of wheat especially for

food security perspective. Extension personnel should encourage farmers to increase wheat area in the locations where ago-climatic factors are suitable for wheat cultivation.

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APPENDIX-I

Area, production and yield of wheat in Bangladesh from 1980-81 to 2005-06

Year	Area	Production	Yield
	000 ha	000 mt	kg/ha
1980-81	591.00	1093.00	1849.41
1981-82	534.00	967.00	1810.86
1982-83	519.00	1095.00	2109.83
1983-84	526.00	1211.00	2302.28
1961-85	676.00	1464.00	2165.68
1985-86	540.00	1042.00	1929.63
1986-87	585.00	1091.00	1864.96
1987-88	597.00	1048.00	1755.44
1988-89	560.00	1022.00	1825.00
1989-90	689.00	890.00	1291.73
1990-91	599.00	1004.00	1676.13
1991-92	575.00	1070.00	1860.87
1992-93	637.00	1150.00	1805.34
1993-94	615.00	1131.00	1839.02
1994-95	640.00	1245.00	1945.31
1995-96	700.00	1369.00	1955.71
1996-97	708.00	1454.00	2053.67
1997-98	805.00	1803.00	2239.75
1998-99	882.00	1908.00	2163.27
1999-00	832.00	1840.00	2211.54
2000-01	772.00	1673.00	2167.10
2001-02	742.00	1606.00	2164.42
2002-03	706.00	1507.00	2134.56
2003-04	567.00	1248.00	2201.06
2004-05	558.00	976.00	1749.10
2005-06	481.00	772.00	1604.99

Sources: BBS, BARI annual report, WRC report, krishi diary of different years.

APPENDIX-II

Inputs used for wheat production in Bangladesh (Per hectare) from 1980-81 to 2005-06

Year	Human Labour (without food)	Draft animal (without food)	Seed	Manure	Urea	TSP	MP	Gypsum	MP & Gypsum	Pesticide	Irrigation	Land rent
	man-days	pair-days	kg	kg	kg	kg	kg	kg	kg	liter	hour	tk
1980-81	102.00	24.06	141.14	1950.00	95.00	72.00	21.00	0.00	21.00	0.18	29.00	1508.20
1981-82	105.00	25.00	149.50	2514.60	86.00	80.00	19.00	0.00	19.00	0.20	28.00	1761.11
1982-83	107.00	26.46	146.91	1790.75	88.00	81.00	21.46	0.00	21.46	0.07	27.00	1486.94
1983-84	115.00	27.02	144.79	1596.93	99.00	75.00	19.25	0.00	19.25	0.02	29.00	1877.20
1984-85	117.00	26.90	142.61	1770.17	102.98	70.00	20.62	0.00	20.62	0.15	24.00	1836.64
1985-86	109.00	22.30	152.62	1930.21	94.00	69.00	20.81	0.00	20.81	0.12	26.00	1844.65
1986-87	109.76	23.61	154.97	2084.06	93.00	76.00	18.00	0.00	18.00	0.10	31.99	1943.85
1987-88	104.00	21.90	156.17	2008.93	89.00	78.00	19.00	0.00	19.00	0.03	25.00	2628.87
1988-89	106.00	26.47	152.52	3112.20	81.00	76.00	22.66	0.00	22.66	0.02	29.00	2751.35
1989-90	118.00	28.25	149.09	1822.93	82.00	71.00	18.02	0.00	18.02	0.02	28.00	2706.15
1990-91	119.00	29.25	158.44	2813.06	87.00	76.00	21.00	40.00	61.00	0.08	29.00	2932.73
1991-92	121.00	28.00	160.50	3531.73	95.00	79.00	25.00	42.00	67.00	0.13	31.00	3009.07
1992-93	118.00	29.58	154.97	2251.29	82.00	76.00	25.00	40.34	65.34	0.12	27.00	2354.62
1993-94	119.00	29.40	153.76	2434.68	80.00	70.00	24.00	41.37	65.37	0.12	26.00	2465.36
1994-95	121.00	30.29	165.64	2857.14	92.00	81.00	23.00	47.98	70.98	0.22	40.00	3440.60
1995-96	124.00	29.66	167.58	3178.26	89.00	78.00	26.00	50.33	76.33	0.23	38.00	3446.70
1996-97	128.00	32.46	168.00	5250.00	98.00	89.00	27.00	61.00	88.00	0.29	35.00	3795.10
1997-98	124.00	34.16	164.92	1645.83	92.00	81.00	28.00	50.00	78.00	0.51	32.00	3989.63
1998-99	126.00	34.43	162.33	3636.36	96.00	83.00	21.00	48.00	69.00	0.61	30.00	4323.00
1999-00	121.00	31.98	165.64	3400.00	89.00	81.00	22.00	49.00	71.00	0.67	28.00	4400.00
2000-01	125.00	33.70	164.81	3076.92	98.00	76.00	23.25	42.00	65.25	0.69	34.09	4323.00
2001-02	127.00	32.96	150.40	3479.17	100.00	80.00	24.24	45.00	69.24	0.64	31.00	4246.00
2002-03	122.00	29.36	152.11	3205.21	102.00	82.00	21.00	43.00	64.00	0.77	30.00	4468.49
2003-04	125.00	28.36	158.83	3215.30	94.00	81.00	23.00	42.00	65.00	0.88	29.00	4702.64
2004-05	124.00	27.74	158.40	2962.11	93.00	75.00	21.00	42.00	63.00	0.94	28.00	4949.06
2005-06	121.00	28.70	147.36	3482.16	89.00	76.00	24.00	41.00	65.00	0.90	33.24	5208.39

Sources: BBS, BARI annual report, WRC report, krishi diary of different years a nd handbook of agricultural technology, 1999. 3rd edition, BARI, Gazipur, Bangladesh

APPENDIX-III

Prices of inputs for wheat production in Bangladesh from 1980-81 to 2005-06

Year	Human Labour (without food)	Draft animal (without food)	Seed	Manure	Urea	TSP	MP	Gypsum	Pesticide	Irrigation	Land rent
	tk/man-day	tk/pair-day	tk/kg	tk/kg	tk/kg	tk/kg	tk/kg	tk/kg	(tk/liter)	tk/hour	tk/ha
1980-81	13.97	21.65	3.50	0.10	2.77	2.23	1.74	0.00	90.00	10.00	1508.20
1981-82	15.48	24.00	5.25	0.10	3.29	2.80	2.19	0.00	100.00	15.00	1761.11
1982-83	17.05	26.60	5.25	0.12	3.97	3.75	2.94	0.00	110.00	16.00	1486.94
1983-84	19.58	31.72	6.75	0.15	3.97	3.75	2.94	0.00	110.00	12.00	1877.20
1984-85	24.45	39.12	7.00	0.12	4.97	4.77	3.76	0.00	120.00	18.00	1836.64
1985-86	29.54	49.33	7.30	0.14	5.06	4.98	3.95	0.00	150.00	17.00	1844.65
1986-87	31.91	51.06	7.30	0.16	4.90	5.11	4.06	0.00	150.00	21.00	1943.85
1987-88	31.15	54.82	8.50	0.15	4.78	4.96	3.91	0.00	160.00	18.00	2628.87
1988-89	30.26	47.21	8.00	0.10	4.80	4.96	3.91	0.00	140.00	28.00	2751.35
1989-90	31.35	47.65	11.00	0.14	4.80	4.96	3.91	0.00	150.00	21.00	2706.15
1990-91	31.19	46.79	12.00	0.18	5.13	5.88	4.74	2.80	160.00	28.80	2932.73
1991-92	33.27	54.90	12.00	0.15	5.46	7.11	6.12	3.08	180.00	30.00	3009.07
1992-93	34.62	54.34	13.00	0.14	5.54	8.15	7.16	3.46	190.00	31.00	2354.62
1993-94	34.92	55.17	11.00	0.19	5.24	8.50	8.04	3.63	200.00	33.00	2465.36
1994-95	35.67	58.12	11.00	0.21	5.74	9.81	7.56	3.61	250.00	30.00	3440.60
1995-96	37.33	58.61	12.00	0.23	5.38	11.87	8.03	3.69	250.00	35.00	3446.70
1996-97	38.04	60.10	13.50	0.20	5.70	13.74	7.93	3.50	260.00	39.00	3795.10
1997-98	46.20	71.61	13.00	0.24	5.95	13.84	8.57	3.54	290.00	32.00	3989.63
1998-99	48.36	70.60	15.00	0.22	6.21	13.82	9.74	3.59	320.00	37.00	4323.00
1999-00	50.52	74.24	14.00	0.25	6.13	12.93	9.40	3.75	300.00	40.00	4400.00
2000-01	51.25	72.78	13.50	0.26	6.11	12.78	9.49	3.70	360.00	44.00	4323.00
2001-02	55.75	79.17	12.50	0.24	6.21	12.84	9.67	3.76	390.00	40.00	4246.00
2002-03	74.60	99.00	14.00	0.28	6.25	13.20	9.75	3.80	380.00	45.00	4468.49
2003-04	75.80	110.00	16.00	0.30	6.50	13.50	10.00	4.50	390.00	49.00	4702.64
2004-05	76.00	120.00	16.00	0.35	6.75	14.00	10.00	4.50	430.00	48.89	4949.06
2005-06	80.00	120.00	17.00	0.32	6.75	16.00	10.00	5.00	430.00	60.00	5208.39

Sources: Various issues of DAM and BBS publications

APPENDIX-IV

Cost of inputs used for wheat production in Bangladesh from 1980-81 to 2005-06

(Fig. in million taka)

Year	Human labour	Draft animal	Seed	Manure	Urea	TSP	MP & GYP	Pest-cides	Imgation	Land -rent	Total cost
1980-81	842	308	292	115	156	95	22	9	171	891	2902
1981-82	868	320	419	134	151	120	22	11	224	940	3210
1982-83	947	365	400	112	181	158	33	4	224	772	3195
1983-84	1184	451	514	126	207	148	30	1	183	987	3831
1984-85	1934	711	675	144	346	226	52	12	292	1242	5633
1985-86	1739	594	602	146	257	186	44	10	239	996	4812
1986-87	2049	705	662	195	266	227	43	9	393	1137	5686
1987-88	1934	717	792	180	254	231	44	3	269	1569	5993
1988-89	1796	700	683	174	218	211	50	2	455	1541	5829
1989-90	2549	927	1130	176	271	243	49	2	405	1865	7616
1990-91	2223	820	1139	303	267	268	127	7	500	1757	7411
1991-92	2315	884	1107	305	298	323	162	13	535	1730	7672
1992-93	2602	1024	1283	201	289	395	203	14	533	1500	8044
1993-94	2556	997	1040	284	258	366	211	15	528	1516	7771
1994-95	2762	1127	1166	384	338	509	222	35	768	2202	9513
1995-96	3240	1217	1408	512	335	648	276	40	931	2413	11020
1996-97	3447	1381	1606	743	395	866	303	53	966	2687	12448
1997-98	4612	1969	1726	318	44	902	336	119	824	3212	14459
1998-99	5374	2144	2148	706	526	1012	332	172	979	3813	17206
1999-00	5086	1976	1929	707	454	871	325	166	932	3661	16107
2000-01	4946	1894	1718	618	462	750	290	193	1158	3337	15365
2001-02	5254	1936	1395	620	461	762	299	186	920	3151	14984
2002-03	6425	2052	1503	634	450	764	260	208	953	3155	16404
2003-04	5372	1769	1441	547	346	620	238	195	806	2666	14000
2004-05	5259	1857	1414	579	350	586	223	225	764	2762	14018
2005-06	4656	1656	1205	536	289	585	214	186	959	2505	12792

Sources: BBS, BARI annual report, WRC report, krishi diary of different years and handbook of agricultural technology, 1999. 3rd edition, BARI, Gazipur, Bangladesh

APPENDIX-V

Total cost, gross return and net return of wheat production in Bangladesh from 1980-81 to 2005-06

Year	Toad cost	Gross return	Net return
	minion tk	million tk	million tk
1980 - 81	2901.63	3703.08	801.45
1981-82	3209.88	3908.61	698.73
*19*82 - 83	3195.34	4815.81	1620.47
1983-84	3831.35	5272.69	1441.35
1984-85	5633.34	6646.56	1013.22
1985-86	4811.75	4516.03	-295.72
1986-87	5685.83	4885.50	-800.33
1987-88	5993.32	5911.77	-81.56
1988-89	5829.41	6181.06	351.65
1989-90	7616.47	5856.20	-1760.27
1990-91	7411.21	6494.88	-916.33
1991-92	7672.47	7793.88	121.41
1992-93	8044.47	6243.35	-1801.12
1943-44	7771.26	6453.49	-1317.78
1996-95	9513.06	9964.98	451.92
1995-,6	11019_67	11038.25	18.57
199iiM	11447.98	11412.45	-1035.53
109'7-96	1445855	16246.83	1788.28
1999-99	17205.56	18660.24	1454.68
1949-00	16107.33	17480.00	1372.67
2000-01	15365.26	15408.33	43.07
2001-02	14983.73	14518.24	-465.49
2002-03	16403.94	14211.01	-2192.93
2003-04	14000.47	12629.76	-1370.71
2004-05	14018.16	10604.24	-3413.92
2005-06	1`2792.04	8708.16	-4083.88

Sources: BBS, BARI annual report, WRC report, krishi diary of different years and handbook of agricultural technology, 1999, 3rd edition, BARI, Gazipur, Bangladesh

APPENDIX-VI

Yield and price of wheat grain and straw from 1980-81 to 2005-06

Year	Yield	Price	Straw	Price
	kg/ha	tk/mt	kg/ha	tk/mt
1980-81	1849.41	3048.00	3236.46	170.00
1981-82	1810.86	3702.00	3169.01	170.00
1982-83	2109.83	4018.00	3692.20	190.00
1983-84	2302.28	3914.00	4028.99	220.00
1984-85	2165.68	4160.00	3789.94	190.00
1985-86	1929.63	3914.00	3376.85	210.00
1986-87	1864.96	4018.00	3263.68	230.00
1987-88	1755.44	5201.00	3072.03	220.00
1988-89	1825.00	5708.00	3193.75	170.00
1989-90	1291.73	6160.00	2260.52	210.00
1990-91	1676.13	5969.00	2933.22	250.00
1991-92	1860.87	6844.00	3256.52	220.00
1992-93	1805.34	5009.00	3159.34	210.00
1993-94	1839.02	5186.00	3218.29	260.00
1994-95	1945.31	7444.00	3404.30	280.00
1995-96	1955.71	7463.00	3422.50	300.00
1996-97	2053.67	7309.00	3593.93	270.00
1997-98	2239.75	8391.00	3919.57	310.00
1998-99	2163.27	9200.00	3785.71	290.00
1999-00	2211.54	8860.00	3870.19	320.00
2000-01	2167.10	8550.00	3792.42	330.00
2001-02	2164.42	8420.00	3787.74	310.00
2002-03	2134.56	8730.00	3735.48	350.00
2003-04	2201.06	9380.00	3851.85	370.00
2004-05	1749.10	10025.00	3060.93	420.00
2005-06	1604.99	10500.00	2808.73	390.00

Sources: Various issues of BBS and DAM publications

APPENDIX-VII

Monthly mean and total rainfall in mm and monthly mean temperature in °C from 1980-81 to 2005-06

Yew	Monthly mean (November to March)	Total (November to March)	Monthly mean(November to March)
	rainfall in mm	rainfall in mm	temperature in °C
1972-73	11.69	58.46	21.86
1973-74	39.97	199.87	21.06
1974-75	22.95	114.73	20.70
1975-76	18.87	94.36	20.46
1976-77	19.79	98.96	21.26
1977-78	17.87	89.36	21.29
1978-79	6.93	34.64	18.27
1979-80	23.18	115.89	19.41
1980-81	23.77	118.87	20.50
1981-82	22.79	113.94	18.82
1982-83	11.55	57.74	19.95
1983-84	31.84	159.20	19.61
1984-85	4.92	24.60	19.91
1985-86	21.04	105.18	20.84
1986-87	24.06	120.32	21.20
1987-88	19.26	96.28	21.47
1988-89	41.14	205.72	21.12
1989-90	5.36	26.78	18.02
1990-91	55.61	278.06	19.14
1991-92	33.58	167.92	19.19
1992-93	18.87	94.33	19.63
1993-94	40.36	201.78	19.63
1994-95	30.56	152.82	20.73
1995-96	45.14	225.71	20.49
1996-97	20-43	10214	21.15
1997-9d	26-77	133.86	20.43
_ 1996-!!	15..67	24336	21.00
19W40	7.05	35.25	21.79
Awaaa	24.79	123.93	20.32

Source: Meteorological department and various issues of BBS publications