Economic Analysis of Rice Production in Bangladesh

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Abstract — The aim of the study is to examine the growth performance and profitability of rice production in Bangladesh using the time series data for the period 1981-82 to 2010-11. The study was based on secondary data. Growth rates of area, production, yield and nominal price of three seasons of rice were estimated by fitting exponential trend function. Growth rates of area which were significantly negative for Aus, Aman that were -4.6 percent and -0.3 percent and positive for Boro rice it was 4.5 percent over the whole period. The growth rates of yield for Aus, Aman and Boro were increased significantly at the rate of 2.2, 1.9 and 1.9 percent respectively during the entire time period. The growth rate of production was significantly negative for Aus rice was 2.4 percent and positive for Aman and Boro rice that were 1.6 and 6.3 percent respectively. There was an upward trend observed in nominal price for Aus, Aman and Boro over the period. The short-run and long-run price elasticity of Aus was 0.010 and 0.210 and short-run and long-run elasticity of Aman and Boro rice were 0.091, 0.112 and 0.051 and 0.395 respectively. The short-run responses in rice production are lower than long-run response as indicated by the higher long-run elasticities. The lagged area variable was highly significant in Aus and Boro rice area response equation. Rainfall in sowing period had significant influences in Aus area response equation. Aman has positive influence with the lagged yield and negative with the irrigated area. Policy related to technological advancement, improving varieties, extension services, fertilizer distribution, high yielding variety seeds and production management research may increase the productivity of food grains in Bangladesh.

Keywords — Economic analysis, price elasticity, price fluctuation, trend analysis, rice cultivation, Bangladesh

I. INTRODUCTION

[The predominance of agriculture in Bangladesh becomes obvious from its contribution to economic development and employment creation [1]. Agriculture being the dominant sector of Bangladesh economy [2], the share of agricultural sector in Gross Domestic Product (GDP) at the beginning of eighties (1980-81) was 33.07 percent which reduced gradually to 29.23 percent in 1990-91, 25.03 percent in 2000-01, 21.85 percent in 2005-06 and 20.24 percent in 2009-10 at constant prices [3]. During 2011-12 the contribution of agricultural sector in GDP was 19.29 percent at current price [4]. Agriculture sector is comprised of four sub sectors, e.g. crops, livestock, forestry and fisheries with crop sub sector being the predominant one [5],[6],[7],[8]. The contribution of these sub sectors are 10.74 percent, 2.50 percent, 1.66 percent and 4.39 percent, respectively. The disaggregation of the country's agriculture GDP reveals that the crop sub-sector alone accounted for about 55.68 percent [9]. Agricultural growth has accelerated from less than 2.0% per year during the first two decades after independence to around 3.0% during the last three decade (FY2011-15) [10].

It provides nearly 48 percent of rural employment, about two-thirds of total calorie supply and about one-half of the total protein intakes of an average person in the country [11],[12],[13],[14]. Besides, rice provides 76 percent of the people's average calorie intake and 66 percent of protein intake consumption. The country is now producing about 33.0 million tons to feed 160 million people [15]. This indicates that the growth of rice production was much faster than the growth of population [16],[17],[18]. This increased rice production has been possible largely due to the adoption of modern rice varieties on around 66 percent of the rice land which contributes to about 73 percent of the country's total rice production [19],[7],[20],[14],[21],[22].

Among the cereals grown rice is the dominant crop and it is grown on more than three fourths of the total cultivable land [23],[24],[25]. Food self-sufficiency mostly depends on rice production. The total contribution of the rice production is about 70 percent of the total agricultural contribution to GDP [26],[27],[28],[29]. Thus, it is often argued that self-sufficiency in food might be attained by enhancing the overall productivity of rice [30]. The contribution of rice to self-sufficiency in food is enormous because currently rice is grown on around 11.53 million

hectares that covers about 77 percent of the total cultivable land in Bangladesh [31]. The share (in percentage) of the Aus rice decreased over the time period. On an average in the period 1981-85 the share of the Aus area was 29.15 percent and in the period 2006-11 the share of Aus area decreased at 9 percent. At the same time, the share of the Aman rice area decreased but the rate of decreasing was not as high as the Aus rice area. The average share was highest in the year 1981-85 and lowest at the year 2006-11 that was 56.96 and 49.30.

On the same time the share of the Boro rice area increased. The increasing rate of the Boro rice was high over the entire period [32]. On an average in the period 1981-85 the share percentage of the Boro rice area was 13.89 percent after that in the period 1991-95 the share percent was 26.33 percent that is double compared with the percent of Boro rice in the year 1981-85. The share percent was highest on average in the year 2006-11 that was 41.80. It shows that the change in the Aman rice area was not much but the area of Aus rice shows the increasing trend line and the Boro rice area shows the positive trend line. This study will open a new lens for policy makers for improving the efficiency of rice sector in Bangladesh. This study is not only an initial effort from this perspective but also provide information for future issues. This study is undertaken to examine the growth performance and profitability of rice production in Bangladesh.

II. METHODOLOGY

A. Selection of Crop and Period

Rice is selected for this study given their overwhelming place and importance in Bangladesh. Practically, all crop sector development strategy and investments so far, predominantly surrounded in rice. Some rice seasons are directly competitive with each other to scarce productive resources and therefore, any policy strategy for one is directly linked to the growth and development of the other. The present study covers the time period of 30 years, the latest data available from 1981-82 to 2010-11 which may be an advancement in terms of information analysis. This entire time period is chosen due to initial start of privatization as well as the rest of the time period to capture the effects of an emerging market enterprise economy.

In accordance with the objectives 1 and 2, the entire data series was divided into three sub-periods viz. period I, period II and period III. The sub-periods were as follows:

1. Sub-Period I: 1981-82 to 1990-91 (10 years)
2. Sub-Period II: 1991-92 to 2000-01 (10 years)
3. Sub-Period III: 2001-02 to 2010-11 (10 years).

B. Selection of Price

In accordance with the selection of rice crop, appropriate price was chosen. Price has an influence on resources allocation and is more important for policy purposes. In fact, farmers take area allocation decisions with respect to the expected prices prevailing during the post harvest period. In the present study harvest price of rice of three seasons has been used for analysis. Harvest price has been taken into consideration for the reason that wholesale and retail prices may not reflect what the farmers actually receive, because they are set at a considerably higher level than what the farmers get. Moreover, in the case of Bangladesh, farmers sell large portion of their products at immediate post-harvest period prices. So, harvest price is the most relevant price for the producer-farmers.

C. Nature and Sources of Data

Times series data of annual harvest price, area, production, yield, agricultural credit disbursement, Boro irrigated area and price of competitive crops and rainfall of three seasons of rice have been used in the present study. The secondary data were collected from various publications of Bangladesh Bureau of Statistics (BBS).

D. Processing of Data

The data were assembled and processed for further analysis. For disentangling inflationary price rise, price of rice crop were converted into real price by deflating by consumer price index (CPI). For the study period, CPI constitutes three base years for that reason, consumer price index (CPI) was converted into single base year (2005-06) by applying backward splicing. Harvest price of rice during current year was transformed into natural logarithm, one period lag of rice price has been used when regression were run for the current period.

E. Analytical Framework

To fulfill the objectives of the study the following analytical framework have been used:

a. Growth estimation

Growth rates in nominal and real price, production, area, and yield of rice crop are estimated for examining the growth performance of the rice crop sector. If the growth rate is not constant but depends on time the compound model cannot describe the actual picture of the growth scenario (Gujarati, 2003). Therefore, before performing growth analysis it was necessary to identify the growth model that best fits the time series data. To know the growth of area, production, yield and price of rice of three seasons in Bangladesh for the period of 1980-81 to 2010-11, the following Exponential model was used:

$$Y_t = ae^{bt} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,

Y_t = Area/production/yield/ price of selected crops in year t

a = intercept

b = coefficient

t = independent variable (time)

Taking the natural logarithm of (1), we can write

$\ln Y_t = \ln a + bt$ ……..(2)

Here, b is the growth rate in ratio scale when multiplied by 100, it expresses percentage growth.

b. Irrigated Area

Irrigated area of the rice seasons plays an important role in decisions making of farmers. This variable has been used as independent variable. The irrigated area of all rice seasons was transformed into natural logarithms (in'000 acres). One period lag of irrigated area has been used in this study as a Nerlovian model requirement.

The final forms of the estimated equation is as follows

$\ln A_t = \theta b_0 + \theta b_1 \ln P_{t-1} + (1-\theta) \ln A_{t-1} + \theta b_2 \ln Y_{t-1} + \theta b_3 \ln RA_t + \theta b_4 \ln IR_{t-1} + \theta b5 \ln YRt\text{-}1 + \theta b6 \ln PRt\text{-}1 + \theta \ln Vt$ ……(3)

Where, $0 \leq \theta \leq 1$

Here,

$\ln A_t$ is area under the crop of concern during the current period

$\ln P_{t-1}$ is deflated product price during the preceding harvest season

$\ln A_{t-1}$ is the lagged dependent area variable

$\ln Y_t$ is expected yield during the current period on the yield trend of preceding two years

$\ln IR_{t-1}$ is the irrigated area during the preceding season

$\ln RA_t$ is the total rainfall during the sowing period in millimeter

$\ln YR_t$ is yield risk in the current period (measured by coefficient of variation of preceding two years yields)

$\ln PR_t$ is for price risk in the current period (measured by coefficient of variation of preceding two years prices)

$\ln V_t$ stands for error term

The formulated equations have been estimated within the Nerlovian dynamic models framework using time series data, the error terms of the estimated equations are postulated to be in auto-regressive structure. The estimation procedure depends on the pattern of the auto-regressive structure of the disturbance term. Computer software package is available by which different scheme auto regressive equations can be estimated through Nonlinear least squares or maximum likelihood estimators which give autocorrelation corrected results [33]. An equation may estimate for different order auto regressive error schemes (e.g. first, second and third order and also for no auto regressive error term) depending on the variable degrees of freedom and the best results obtained in terms of higher explanatory power and the higher number of significant coefficients. When auto regressive parameters in auto regression schemes are not significant, the ordinary least squares estimator is used.

III. RESULTS AND DISCUSSION

A. Estimation of growth rates of area, production, yield and price on three seasons of rice crop

The performance of rice sector has a considerable bearing on the rate of growth of the economy. In Bangladesh, the performance of the rice crop sector is the most important determinant of the growth in agricultural production and to a large extent the growth of the economy [34]. Thus the variability of rice crop production can have serious destabilizing consequences on the country's national income, employment and its balance of payment [35]. Analysis of growth rates in area, production and yield can be most useful for policy making since they help to understand the magnitudes and direction of the changes taking places. Data are also divided into three sub periods for comparison among the periods. Growth rates in area, production, yield and price of Aus, Aman, and Boro were computed to have a comparative measure to see the relative growth and their relationship during three decades (1981/82 to 2010/11).

a. Growth rates in area of all rice seasons

At first, an attempt was made to evaluate the results of the exponential trend function fitted to area of different seasons of rice for the period I (1981/82 to 1990/91), II (1991/92 to 2000/01), III (2001/02 to 2010/11) and entire time period (1981/82 to 2010/11). The results are presented in Tables 1 to 4.

Table 1. Growth rates and price of three rice seasons for period of 1981/82 to 2010/11

Variables	Aus b	Aman b	Boro b
Area	-0.046(-4.6)	-0.003(-0.3)	0.045(4.5)
Production	-0.024(-2.4)	0.016(1.6)	0.063(6.3)
Yield	0.022(2.2)	0.019(1.9)	0.019(1.9)
Price	0.042(4.2)	0.043(4.3)	0.04(4.00)

Note: Values in the parentheses indicate % growth rates.

Aus rice

During the entire period Aus area was decreased at the rate of 4.6 percent per annum during the period 1981/82 to 2010/11 (Table 1). The area of Aus rice has declined significantly during the entire study period.

The rates of declining were not same at all the three sub-periods. Sometimes the rate is high and some time the rate is low. Area of Aus has been shown significant negative growth rate in the sub-period I (1981/82 to 1990/91) which is 4.3 percent. However, it is observed that the growth rates of the Aus are significantly negative that is 3.6 percent for the sub-period II (1990/91 to 2000/01). After that period it was observed that the growth rates of the Aus area was also decreased significantly which is 2.2 percent for the sub-period III (2001/02 to 2010/11) (Table 2). The growth rate of the Aus area is significantly negative. The growth rates of the Aus rice areas were higher in the sub-period I and lower at the sub-period III because the farmers were influenced with the modern technology.

Table 2. Exponential trend function fitted to Aus area

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	-0.043(-4.3)	-7.037	.000
II (1991/92 to 2000/01)	-0.036(-3.6)	-9.603	.000
III (2001/02 to 2010/11)	-0.022(-2.2)	-2.035	.076

Note: Values within parentheses indicate percentage growth rates.

Aman rice

In the present study the area of Aman has been decreased significantly at the rate of 0.3 percent during the entire period 1981/82 to 2010/11 (Table 1). But the rates of declining were not same at all the three sub-periods. Sometimes the rate is high and sometime the rate is low and also being positive and negative. Area of Aman has shown negative growth rate in the period 1981/82 to 1990/91which is higher than the growth rate of Aman area for the entire period.

Table 3. Exponential trend function fitted to Aman area for different sub-periods

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	-0.010(-1.0)	-1.859	.100
II (1991/92 to 2000/01)	-0.003(-0.3)	-0.713	.496
III (2001/02 to 2010/11)	-0.002(-0.2)	-0.437	.674

Note: Values within parentheses indicate percentage growth rates.

It is observed that the growth rates of the Aman are insignificantly negative that is 0.3 percent for the next sub-period 1991/92 to 2000/01 (Table 3). After that period we observed that the growth rates of the Aman area is also decreased insignificantly which is 0.2 percent for the time period 2001/02 to 2010/11. In Table 3, the growth rates of the Aman area was negative but these rates are not same for the all sub-period. The decreasing rate was high in the sub-period I and low at the sub-period III. For the period I the rate was significant but the rates were insignificant for the other two periods.

Boro rice

During the time period, area of Boro has been increased significantly at the rate of 4.5 percent during the period 1981/82 to 2010/11 (Table 1). The rates of increased were not same at all the sub-periods. Sometimes the rate is high and sometime the rate is low, again it can be positive or negative. Area of Boro has been shown significant positive growth rate in the period 1981/82 to 1990/91 which is 8.1 percent; it was higher than the growth rate of Boro rice for entire time period. It was observed that the growth rates of the Boro are significantly positive but the rates gradually decrease that is 4.5 percent for the next sub-period 1991/92 to 2000/01. The growth rates decrease that is it decreases 3.6 percent than the previous sub-period. After that period it was observed that the growth rates of the Boro area was increased significantly which is 3 percent for the time period 2001/02 to 2010/11(Table 4). The growth rates of the sub-periods I and II were lower than the growth rate of the entire time period.

Table 4. Exponential trend function fitted to Boro area

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.081(8.1)	9.256	.000
II (1991/92 to 2000/01)	0.045(4.5)	6.044	.000
III (2001/02 to 2010/11)	0.030(3.0)	12.337	.000

Note: Values within parentheses indicate percentage growth rates

b. Growth rates in production of all rice seasons

The exponential trend function fitted to Production of different rice seasons for the period I (1981/82 to 1990/91), II (1991/92 to 2000/01), III (2001/02 to 2010/11) and entire period (1981/82 to 2010/11). The results are presented in Tables 1 and 5 to 7.

Aus rice

During the entire time period production of Aus rice was observed negative growth rate. The production of Aus had decreased at the rate of 2.4 percent annually (Table 1). The production of Aus rice has declined significantly during the entire study period. The rates of decreased were not same at all the three sub-periods. Sometimes the rate is high and some time the rate is low. Production of Aus has been shown significant negative growth rate in the sub-period I (1981/82 to 1990/91) which is 2.7 percent. This means that during the time period the production of Aus rice was decreased at 2.7 percent per annum. This was higher than the decreased rate of the total Aus rice production for thirty years. The growth rate of Aus rice production was significantly negative that is 1.8 percent for the sub-period II (1991/92 to 2000/01). After that period it was observed that the growth rate of the Aus production was positive for the sub-period III (2001/01 to 2010/11) that was 0.6 percent (Table 5).

Table 5. Exponential trend function of Aus rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	-0.027(-2.7)	-3.350	.010
II (1991/92 to 2000/01)	-0.018(-1.8)	-1.999	.081
III (2001/02 to 2010/11)	0.006(0.6)	0.444	.669

From the table we saw that the growth rate of Aus production for the first two sub-periods were significantly negative that means the production of Aus rice for the sub-periods decreased annually. The growth rate of the production of Aus rice was positive in the sub-period III.

Aman rice

In the entire period production of Aman rice showed positive growth rate. The production of Aman has increased at the rate of 1.6 percent annually (Table 1). The production of Aman rice was increasing significantly during the entire study period. But the rates of increased were not same at all the sub-periods. Sometimes the rate was high and sometimes the rate was low. Production of Aman showed significant positive growth rate in the sub-period I (1981/82 to 1990/91) which was 1.8 percent. This means that during the time period the production of Aman rice was increased at 1.8 percent per annum. This was higher than the growth rate of the Aman rice production for the total thirty years. The growth rate of the Aman rice production was insignificantly positive that is 0.8 percent for the sub-period II (1991/92 to 2000/01). After that period the growth rate of the Aman production was insignificantly positive for the sub-period III (2001/01 to 2010/11) that was 1.4 percent (Table 6). From the table we saw that the growth rate of the Aman production for all the sub-periods was positive that means the production of Aman for the all sub-periods increased annually. The growth rate was higher in the sub-period I and sub-period III compared to the sub-period II.

Table 6. Exponential trend function fitted to production of Aman rice for different sub-periods

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.018(1.8)	1.911	.092
II (1991/92 to 2000/01)	0.008(0.8)	0.723	.490
III (2001/02 to 2010/11)	0.014(1.4)	1.497	.173

Boro rice

In the entire period the production of Boro rice showed positive growth rate. The production of Boro increased at the rate of 6.3 percent annually (Table 1). Production of Boro rice also showed significantly positive growth rate in the sub-period I (1981/82 to 1990/91) which was 8.5 percent. This means that during the time period the production of Boro rice increased at 8.5 percent per annum. This was higher than the growth rate of the Boro rice production for entire time period. It is observed that the growth rate of the Boro rice production was significantly positive that was 7.0 percent for the sub-period II (1991/92 to 2000/01). After that period we observed that the growth rate of the Boro production was significantly

positive for the sub-period III (2001/01 to 2010/11) that was 5.7 percent (Table 7). From the table we saw that the growth rate of the Boro rice production for all the sub-periods was significantly positive that means the production of Boro for the all sub-periods increased annually. So the production of Boro rice increases and the increasing rate of the Boro rice production are comparatively higher than the Aus and Aman rice production [36].

Table 7. Exponential trend function fitted to production of Boro rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.085(8.5)	9.410	.000
II (1991/92 to 2000/01)	0.070(7.0)	6.342	.000
III (2001/02 to 2010/11)	0.057(5.7)	13.066	.000

c. Growth rates in yield of all rice seasons

Yield of a crop is the reflection of technological advancement in production activities. Increase in crop yield acts as real indicator of progress in crop production activities. The exponential trend function fitted to yield of different rice seasons for the period I (1981/82 to 1990/91), II (1991/92 to 2000/01), III (2001/02 to 2010/11) and entire period (1981/82 to 2010/11). The results are presented in Tables 1 and 8 to 10.

Aus rice

During the entire time period the yield growth of the Aus rice was found to be 2.2 percent per annum. The growth rate of yield of Aus rice was positive and significant during the entire period (Table 1). The yield of Aus rice increased significantly during the entire study period. But the rates were not same at all the three sub-periods. Sometimes the rate was high and sometimes the rate was low. Yield of Aus had been shown significant positive growth rate in the sub-period I (1981/82 to 1990/91) which was 1.6 percent. This means that during the time period the yield of Aus rice was increased at 1.6 percent per annum. This was lower than the growth rate of the yield of Aus rice for the thirty years. It was observed that the growth rate of the Aus rice yield was significantly positive that is 1.8 percent for the sub-period II (1991/92 to 2000/01). This means that during the time period the yield of Aus rice increased at 1.8 percent per annum.

Table 8. Exponential trend function fitted to yield of Aus rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.016(1.6)	3.408	.009
II (1991/92 to 2000/01)	0.018(1.8)	2.353	.046
III (2001/02 to 2010/11)	0.028(2.8)	6.891	.000

After that period the growth rates of the yield of Aus was significantly positive for the sub-period III (2001/01 to 2010/11) that was 2.8 percent (Table 8). This means that during the time period the yield of Aus rice was increased at 2.8 percent per annum for the use of chemical fertilizer, pesticides etc. From the table we see that the growth rate of the Aus yield for all sub-periods was significantly positive that means the yield of Aus for the all sub-periods increased annually.

Aman rice

In the entire time period the yield growth of the Aman rice was found to be 1.9 percent per annum. The growth rate of yield of Aman was positive and significant during the entire period. The yield of Aman rice was increasing significantly during the entire study period. But the rates of increased were not same at all the sub-periods. Sometimes the rate was high and sometimes the rate was low. Yield of Aman showed significant positive growth rate in the sub-period I (1981/82 to 1990/91) which was 2.8 percent. This means that during the time period the yield of Aman rice was increased at 2.8 percent per annum. This was higher than the growth rate Aman rice yield for the total thirty years. It is observed that the growth rate of the Aman rice yield was insignificantly positive that was 1.1 percent for the sub-period II (1991/92 to 2000/01). After that period the growth rates of the Aman yield were significantly positive for the sub-period III (2001/01 to 2010/11) that was 1.5 percent (Table 9).This means that during the time period the yield of Aman rice increased at 1.5 percent per annum. The growth rate was higher in the sub-period I and sub-period III compare to the sub-period II.

Table 9. Exponential trend function fitted to yield of Aman rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.028(2.8)	5.195	.001
II (1991/92 to 2000/01)	0.011(1.1)	1.248	.247
III (2001/02 to 2010/11)	0.015(1.5)	3.331	.010

Note: Values within parentheses indicate percentage growth rates.

Boro rice

During the entire time period the growth of yield of Boro rice was found 1.9 percent per annum. It was positive and significant growth rate during the whole period. Yield of Boro showed significant positive growth rate in the sub-period I (1981/82 to 1990/91) which was 0.3 percent. This means that during the time period the yield of Boro rice was increased at 0.3 percent per annum. However, it was observed that the growth rate was significantly positive that is 2.5 percent for the sub-period II(1991/92 to 2000/01).This means that during the time period the yield of Boro rice was increased at 2.5 percent per annum for the sub-period II. After that period we observed that the growth rate of the Boro yield was significantly positive for the sub-period III (2001/01 to 2010/11) that was 2.7 percent (Table 10).This means that during the time period the yield of Boro rice was increased at 2.7 percent per annum. From the table we saw that the growth rate of the Boro yield for all the sub-periods was significantly positive that means the yield of Boro for the all sub-periods increased annually. From the table, the growth rate was significantly positive and the rate was increased annually.

Exponential trend function of Boro rice

d. Growth rates of price for all rice seasons

The exponential trend function fitted to price of different rice seasons for the period I (1981/82 to 1990/91), II (1991/92 to 2000/01), III (2001/02 to 2010/11) and entire period (1981/82 to 2010/11). The results are presented in Tables 1 and 11 to 13.

Aus rice

During the entire period nominal price of Aus rice had a significant positive growth rate. Nominal price of Aus rice increased at a rate of 4.2 percent per annum. In sub-period I (1981/82 to 1990/91) Aus rice price increased significantly at the rate of 7.2 percent per annum. In sub-period II (1991/92 to 2000/01), Aus rice price had been increasing but not significantly 0.7 percent per annum only. The growth rate was very low compare to the growth rate of the period I. In sub-period III (2001/02 to 2010/11), Aus price had been increasing significantly at a rate of 13.1 percent per annum. The growth rate is very high compare to the growth rate of the period I and Period II because of inflation rate (Table 10).

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.003(0.3)	2.178	.061
II (1991/92 to 2000/01)	0.025(2.5)	5.746	.000
III (2001/02 to 2010/11)	0.027(2.7)	11.859	.000

Table 10. Exponential trend function fitted to harvesting price of Aus rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.072(7.2)	7.763	.000
II (1991/92 to 2000/01)	0.007(0.7)	0.401	.699
III (2001/02 to 2010/11)	0.131(13.1)	9.036	.000

Note: Values within parentheses indicate percentage growth rates.

Aman rice

Over the whole period of 1981/82 to 2010/11, the nominal price of Aman rice was observed to have a significant positive growth trend at a rate of 4.3 percent per annum. In sub-period I (1981/82 to 1990/91), nominal price of Aman rice was observed to have a significant positive growth trend at a rate of 5.9 percent per annum. In sub-period II (1991/92 to 2000/01), nominal price of Aman rice was observed to have an insignificant but positive growth trend at a rate of 2.5 percent per annum. Over the sub-period III (2001/02 to 2010/11), nominal price of Aman rice was observed to have a significant positive at a rate of 13.6 percent per annum. The growth rate was higher in the sub-period III compare to the other sub-periods.

Table 11. Exponential trend function fitted to harvesting price of Aman rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.059(5.9)	6.123	.061
II (1991/92 to 2000/01)	0.025(2.5)	1.348	.000
III (2001/02 to 2010/11)	0.136(13.6)	15.952	.000

Note: Values within parentheses indicate percentage growth rates.

Boro rice

Over the whole period of 1981/82 to 2010/11, nominal price of Boro rice was observed to have a significant positive growth trend at a rate of 4 percent per annum. Again over the period I (1981/82 to 1990/91), nominal price of Boro rice was observed to have a significant positive growth trend at a rate of 6.1 percent per annum. In the period II (1991/92 to 2000/01), nominal price of Boro rice was observed to have a significant positive growth trend at a rate of 3.3 percent per annum.

Table 13. Exponential trend function fitted to harvesting price of Boro rice

Sub-periods	Regression Co-efficient	t-values	Significance values
I (1981/82 to 1990/91)	0.061(6.1)	9.451	.000
II (1991/92 to 2000/01)	0.033(3.3)	2.696	.027
III (2001/02 to 2010/11)	0.103(10.3)	11.893	.000

Note: Values within parentheses indicate percentage growth rates.

Again over the sub-period III (2001/02 to 2010/11), nominal price of Boro rice was observed to have a significant positive at a rate of 10.3 percent per annum. The growth rate was higher in the sub-period III compare to the other sub-periods.

B. Comparative analysis of growth rates of all rice seasons

The area under Aus was decreased by 4.6 percent and area under Boro rice increased by 4.5 percent which shows that the change in Aus rice area was highest compare to the Aman and Boro rice during the entire period. The significant growth rate of Aman rice area indicates that this was decreased by 0.3 percent per annum during the entire period of time. Production under Aus rice declined in total period whereas Aman and Boro rice production showed significantly positive growth rate in same period. Production of Boro rice has rapidly increased relative to Aus and Aman rice in sub-periods I, II, III and entire period. In whole period, yield of all rice seasons had a significantly positive growth rate 2.2 percent, 1.9 percent and 1.9 percent for Aus, Aman and Boro rice respectively. It is encouraging to say that yield growth rate of Aus, Aman and Boro rice have improved in sub-periods II and III compared to sub-period I. The prices of all rice seasons were significantly positive in period I. But in period II, rice prices of all rice seasons were not significantly the price of the Boro rice was significant. The highest growth rates of harvested price of Aus, Aman and Boro rice observed in sub-period III were 13.1 percent, 13.3 percent and 10.6 percent respectively.

IV. CONCLUSION

The focus of the present study was to examine the growth performance and profitability of rice production in Bangladesh. The study also focuses on analyze the acreage response and estimation of growth rates in area, production, yield and nominal price of rice crop in Bangladesh. The study covered the time period of 1981/82 to 20010/11. The base period was chosen due to the initial start of privatization as well as the rest of the period to capture the effect of the liberalized economy. The study was entirely based on secondary data. Bangladesh has achieved remarkable success in attaining near self-sufficiency in rice production, a strategic staple for the country. The growth in rice production from 1981/82 through 2010/11 as exceeded the growth in population. The increase in rice production has occurred through intensive use of modern technology and under the adverse conditions of falling real rice prices, sharply rising agricultural wage rates, and declining availability of land for cultivation. Inputs relating to seed-fertilizer-irrigation technology and their productivity have been the major source of growth. Liberalizations of the import of agricultural equipment (shallow tube well engines and power tillers), particularly the removal of restrictions on import conditioned by public specification of standards, resulted in a flood of supplies of cheap equipment. Farmers responded enthusiastically to adopt these machines. Competition in fertilizer distribution has kept stable supply at market price.

Therefore, time series data for the period 1981/82 to 2010/11 were employed for this study. Rice is the principal cereal crop. Rice is the largest with an

average 71 percent share of the gross output value of crops and total rice crop covers 78.26 percent of the total cropped area. Rice production has doubled since independence without further increase in rice area. Growth rates of area, production, yield and price of rice crops were estimated by fitting exponential function. During the overall study period for the country as a whole, growth rates of area which were negative for Aus, Aman that was 4.6 and 0.3 percent respectively. The areas of Boro increased significantly at the rate of 4.5 percent during the period (1981/82 to 2010/11). The growth rates of yield for Aus, Aman and Boro was increased significantly at the rate of 2.2, 1.9 and 1.9 percent respectively during the entire time period. The contribution of yield to increase production can be considered to be the technological improvement and adoption of technologies by the farmers. Substantial technological progresses have taken place in crop production activities. Increase in production may be attained through increased area allocation from alternative uses and through yield increases. Area and yield increased in Boro which increased the production at the rate of 6.3 percent during the study period (1981/ 82 to 2010/11). Increased growth rate of yield of Aman increased total production at the rate of 1.6 percent while area decreasing significantly at the rate of 0.3 percent. In spite of increasing the yield of Aus, the production of Aus rice deceased during the whole period (1981/82 to 2010/11) due to declining areas of Aus rice crops. The growth rates of nominal price for Aus, Aman and Boro was increased significantly at the rate of 4.2, 4.3 and 4 percent respectively during the entire time period. On the basis of the findings of this study the following steps may be taken to put forward for formulation of policy with a view to improving the existing situation.

a) Area adjustment problems may be removed by ensuring supply of inputs, insecticides and pesticides and credit in proper time.
b) Forecasting of price, target area, yield and production before sowing will be helpful to the farmers in allowing them to adjust the area.
c) Agricultural research efforts should be made towards varietals improvement for increasing their yields.
d) Policy related to technological advancement, improving varieties, extension services, fertilizer distribution, HYV seeds and production management research may increase the productivity of food grains in Bangladesh.

Irrigation water is important for increasing rice production in Bangladesh. Policy related to availability of irrigation equipment and subsidies on fuel and electricity may be more effective for increasing productivity, although the government of Bangladesh has a policy to give subsidy on fuel and electricity for irrigation water).

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