Acreage Response and Price Fluctuation of Rice in Bangladesh

International Journal of Pure Agricultural Advances
Vol. 3, No. 1, 22-39, 2019
e-ISSN: 2523-9538

Check for updates

(Corresponding Author)

Md Forhed Bin Khalique[1]
Md Moniruzzaman[2]
Sarker Md Touhiduzzaman[3]
Md Shahidul Islam[4]
Hilarius Murmu[5]
Elizabeth Rozario[6]
Md Harun Or Rashid[7]

[1,2]*Department of Agribusiness & Marketing, Bangladesh Agricultural University, Mymensingh, Bangladesh.*
[1]*Email: scholarzone.cn@yahoo.com*
[2]*Email: ahmed.cn@yahoo.com*
[3]*Department of Poultry Nutrition and Feed Science, Yangzhou University, Jiangsu, China.*
[3]*Email: tmsarker308@gmail.com*
[4]*Department of Plant Pathology, Yunnan Agricultural University, Kunming, China.*
[4]*Email: islam_ynau@163.com Tel: 8613211687412*
[5,6]*College of Economics & Management, Yunnan Agricultural University, Kunming, China.*
[5]*Email: hilari6@gmail.com*
[6]*Email: uddipona@yahoo.com*
[7]*Department of Management, University of Dhaka, Dhaka, Bangladesh.*
[7]*Email: harunmgt@yahoo.com*

ABSTRACT

The aim at the study is to examine the annual price fluctuation, and acreage response of rice in Bangladesh using the time series data for the period 1981-82 to 2010-11. Acreage response was estimated within the Nerlovian Partial Adjustment Model. The study estimates the growth rate of the area, production, yield and nominal price of rice and annual fluctuation on nominal and real prices of all the three rice seasons. The study was based on secondary data. Price fluctuation of Aus rice for nominal and real price was highest (-26.6 to 46.9) and (-29.4 to 37.2) in sub-period II (1991-92 to 2000-01). The fluctuation in nominal and real price of Aman rice was also highest (-27.0 to 40.7) and (-29.7 to 29.2) in the sub-period II (1991-92 to 2000-01). The fluctuation in nominal and real Boro rice price was also highest (-48.5 to 28.5) and (-34.4 to 28.4) in the sub-period II (1991-92 to 2000-01). 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. Farmer's field-oriented policy should be developed for high yield and stable market.

Keywords: *Rice cultivation, Agricultural marketing, Agricultural economics, Agribusiness, Price determination, Price elasticity.*

DOI: 10.20448/813.31.22.39
Citation | Md Forhed Bin Khalique; Md Moniruzzaman; Sarker Md Touhiduzzaman; Md Shahidul Islam; Hilarius Murmu; Elizabeth Rozario; Md Harun Or Rashid (2019). Acreage Response and Price Fluctuation of Rice in Bangladesh. International Journal of Pure Agricultural Advances, 3(1): 22-39.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
History: Received: 8 August 2019/ Revised: 12 September 2019/ Accepted: 15 October 2019/ Published: 28 November 2019
Publisher: Online Science Publishing

Highlights of this paper

- This study intends to examine the annual price fluctuation and acreage response of rice.
- The fluctuation in the fluctuationd real price of Aman rice was also highest (-27.0 to 40.7) and (-29.7 to 29.2) in the sub-period II (1991-92 to 2000-01).
- Farmer's field-oriented policy should be developed for high yield and stable market.

1. INTRODUCTION

Bangladesh is a developing country having an area of 1, 47,570 square kilometers and the pressure of growth of the population expands demand for the food and other basic needs day by day (BBS, 2007). Rapid population growth increased food demand, and urbanization are exerting tremendous pressure on agricultural land, making it an increasingly scarce resource (Sarker, 2016a). Agricultural land is being transformed into non-agricultural (1 percent) uses that hamper agricultural production (Barmon and Chaudhury, 2012). Hence, per capita agricultural land (12.5 decimals) is declining over the years in Bangladesh. Agriculture has been playing a pioneering role in the economic growth and stability of the national economy of Bangladesh (Sarker *et al.*, 2015). Among the total population, 65 percent are engaged in agriculture of which 48.07 percent is the direct labor force engaged in the sector. The climate and the temperature are favorable for the growth of crop throughout the year (Sarker, 2016b). The most important issue in Bangladesh agriculture is to enhance and sustain growth in crop production (Islam *et al.*, 2015a). Crop production structure, changing production trends of different agricultural products are prerequisites for a better understanding for the study of agricultural growth as well as the economic development of Bangladesh (Sarker *et al.*, 2017).

Despite such a steady growth in agriculture as well as in food production, Bangladesh has been facing persistent challenges in achieving food security (Sarker *et al.*, 2019). At the present stage of Bangladesh's development, overall performance of the economy is inextricably linked to the performance of the agricultural sector (Prodhan *et al.*, 2017). The agricultural sector is the mainstay of the Bangladesh economy. It accounts for over 45 percent of the national value-added. Over 90 percent of the population depends on agriculture directly or indirectly for their incomes (Sarker and Jie, 2017). In the years to come, agriculture will continue to remain the prominent sources of employment for the incremental labor force although the contribution of agriculture in the national economy declining compare to the other sectors (Sarker and Sultana, 2017). It implies that service sector contributes more in the economy followed by industry sector (Islam *et al.*, 2015b). The agriculture sector contributes less than these two sectors. The contribution of agricultural and service sectors is declining because of higher contribution of industry sector in the overall economy (Islam *et al.*, 2018; Nasrin *et al.*, 2019; Sarker *et al.*, 2019).

Although the growth rate is declining day by day but agriculture is the driving forces behind economic growth in Bangladesh and as a result, increasing food and agricultural production have always been major concerns of Bangladesh policymakers (Sarker *et al.*, 2017; Cao *et al.*, 2019; Sarker, 2019b). About 114 countries grow rice and more than 50 have an annual production of 100,000 tons or more. Asian farmers produce about 90 percent of the total, with two countries, China and India, growing more than half of the total crop. For most rice-producing countries where annual production exceeds one million ton, rice is the staple food. In Bangladesh, Cambodia, Indonesia, Myanmar, Thailand, and Vietnam, rice provides 50 percent to 80 percent of the total calories consumed.

In forecasting production, an understanding of the prices to which farmers respond is important. Area allocation represents both production target and response to price of respective crop (Sarker *et al.*, 2019). The farmer can be expected to choose that price of the crop which has increased more than the others. The behavior of rainfall, new farm technology and price of competitive crops has a great bearing on area allocation of rice (Sarker *et* *al.*, 2019). Privatization and deregulation policies in modern agriculture input markets have influenced the rapid diffusion of new technologies in Bangladesh (Sarker *et al.*, 2019). Liberalization of modern agriculture input markets in Bangladesh contributed to increase in total output and in labor productivity growth during the privatization period (Sarker *et al.*, 2019). Technological change is an important factor in economic growth and development. Any change in technology in production will be reflected in achieving higher yields and reducing cost of production (Sarker, 2019a).

Bangladesh is still at the take off stage in terms of use of high yielding varieties by farmers. A high degree of variability in food grain production also means that farmers will be reluctant to adopt high cost-high risk new technologies when they perceive yield fluctuations to a great extent (Karim *et al.*, 2016). The supply response in agriculture is a crucial research issue related with agricultural terms of trade in a small developing economy. It is a prime concern to enhance the growth of crop production through increasing land productivity to meet the increasing food demand for the vast population of the country (Sarker *et al.*, 2019; Sarker *et al.*, 2019). One of the most important issues in agricultural development economics is supply response of crops. This is because the responsiveness of farmers to economic incentives determines agriculture contribution to the economy especially where the sector is the largest employer of the labor force. This is often the case in third world low-income countries (Alam *et al.*, 2019; Alam *et al.*, 2019; Sarker *et al.*, 2019; Sarker *et al.*, 2019). Agricultural pricing policy plays a key role in increasing farm production. Supply response is fundamental to an understanding of this price mechanism (Yap, 1997).

Knowledge of rice supply response or acreage response is crucial to the formulation of agricultural policy in Bangladesh in the view of the fact that price policy can be expected to increase agricultural production. It can help planners and policymakers to achieve production targets. It thus provides a framework for adjusting production to the optimum resource employment to promote economic development. The rice acreage response equations can be used to forecast the rice supplies in the future. This requires regular rice acreage response analysis from time to time to improve the reliability of the supply parameter, which is formulation of agricultural policy (Chowdhury, 2013). It is observed that farmers adjust their production on the basis of price phenomenon in the market. Price mechanism and its impact on farmers' supply behavior are crucial issue for policy makers. In this connection price incentives or price support mechanism accelerate rice output in a country like Bangladesh. For this reason, farmers' reaction or response to financial incentives is a prime concern for policy makers and for the government.

Nerlovian Partial Adjustment Model was utilized for said purpose. This has been a pioneering model to analyze farmer's response behavior and dominated the researchers on the dynamic behavior of farmers in crop production activities since 1958 when Marc Nerlove first innovated and applied this model in agriculture. The main advantage of Nerlovian supply response model is that it is simple and relevant in terms of data requirements and has been considered to be efficient for estimating short-run and long-run elasticity (Haile *et al.*, 2015). The present study opens new directions for policy making authorities to improve the efficiency of rice sector which is backbone of the economy. Rice pricing policy plays a key role in increasing both farm production and incomes and fundamental to an understanding of this price mechanism is supply response. This study is not only an initial effort from this perspective but also provides information for future issues. It is important to understand the supply response phenomena of rice crops in order to implement the right policies for improving this sector and to promote general economic development of the country. The keen interest of this study is to analyze the annual price fluctuation and price trend of rice and to examine the extent of acreage response of rice crops in Bangladesh.

2. METHODOLOGY

2.1. Selection of Crop and Period

Rice is selected for this study given their overwhelming place and importance in Bangladesh. 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 objective, the entire data series was divided into three sub-periods viz. period I, period II and period III. The sub-periods were as follows:

Sub-Period I: 1981-82 to 1990-91 (10 years).

Sub-Period II: 1991-92 to 2000-01 (10 years).

Sub-Period III: 2001-02 to 2010-11 (10 years).

2.2. 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.

2.3. Processing 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). 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.

2.4. Analytical Framework

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

2.4.1. Methods of Estimating Annual Fluctuation and Trend Analysis in Rice Price

In agriculture, principal factor in yearly price variability is changes in supply. The supply available in any one year is based mainly on current production and perhaps to some extent on imports and on carryover from the previous crop year. Following formula was used for measuring the extent of year to year price fluctuation:

$$\text{Price fluctuation } = \frac{Current\ year\ price - previous\ year\ price}{previous\ year\ price} \times 100$$

Coefficient of Variation (CV), was used to measure the price fluctuation over the time period and compare between prices of rice for different seasons.

$$CV = \frac{Standard\ deviation}{Mean}$$

To examine the trend of rice price, both the graphical method and linear trend methods were used in terms of nominal and real price of three season of rice. To construct the real price harvest prices were deflated by the Consumer Price Index (CPI) with 2005-06 as the base year to arrive at real prices of rice. To get the real price, the following formula was applied:

$$\text{Real price} = \frac{Nominal\ price}{Consumer\ price\ index\ (CPI)} \times 100$$

To estimate the trend, the following equation was applied:

$$Y = a + bt$$

Where,

Y = Price (nominal and real) of the rice.

a = intercept.

b = coefficient.

t = independent variable (time).

2.4.2. Methods of Estimating Acreage Response of Rice

Static model means when only one variable is used as an independent variable in the model. Therefore, the desired area to be allocated to a particular crop is a function of the above factors which algebraically can be represented as:

$$A^*_t = f\,(P^*_t, Y^*_t, RA_t, IR_t, YR_t, PR_t).$$

If the relationship is linear then the formal equation becomes:

$$A^*_t = b_0 + b_1P^*_t + b_2\,Y^*_t + b_3\,RA_t + b_4\,IR_t + b_5YR_t + b_6PR_t + V_t$$

Where,

A^*_t = Desire area at time t.

P^*_t = Expected price at time t.

Y^*_t = Expected yield at time t.

RA_t = Rainfall during sowing/planting period at time t.

IR_t= Irrigated area at time t.

YR_t = Yield risk variable at time t.

PR_t = Price risk variable at time t.

V_t = A random residual term.

2.4.3. Nerlovian Area Adjustment Model

Nerlovian Area Adjustment model was used for estimating supply response. This is one of the simple dynamic models. The model implies that the changes in current area are the proportion to the difference between the long run equilibrium area and on actual area in the previous year. The double log (natural) form of the Nerlovian partial model was employed in view of its suitability to the data. Hence, we get the following equations:

$$A_t - A_{t-1} = \theta\,(A^*_t - A_{t-1})$$

$$A_t = \theta\,A^*_t - \theta\,A_{t-1} + A_{t-1}$$

$$A_t = (1\text{-}\theta)\,A_{t-1} + \theta\,A^*_t$$

Where,

A_t - A_{t-1} = Actual change in area between current and last period.

A_t = Actual area at time period t.

A_{t-1} = Actual area at one period back.

A^*_t = Desire area at period t.

= Area adjustment coefficient between the actual area and desire area.

Reduced form of the area adjustment equation through a substitution method is obtaining using above equation, and area adjustment equation is as follows:

$$A_t = \theta b_0 + \theta b_1 P_{t-1} + (1-\theta) A_{t-1} + \theta b_2 Y_{t-1} + \theta b_3 RA_t + \theta b_4 IR_{t-1} + \theta b_5 YR_{t-1} + \theta b_6 YR_{t-1} + \theta V_t$$

Where Y_{t-1} represents expected yield in current period and subscript t-1 signifies the variable lagged by one period, other variables are defined before and assuming last period price is the expected normal price.

The theoretical models explained in equation may be restated after taking logarithms. The estimated reduced form of the area adjustment equation becomes:

$$\ln At = \theta b0 + \theta b1 \ln Pt\text{-}1 + (1-\theta) \ln At\text{-}1 + \theta b2 \ln Yt\text{-}1 + \theta b3 \ln RAt + \theta b4 \ln IRt\text{-}1 + \theta b5 \ln YRt\text{-}1 + \theta b6 \ln YRt\text{-}1 + \theta \ln Vt$$

Estimation of the above equations helps to obtain elasticity coefficients directly. In the supply response Equation 5, signs of the coefficients of price, area, rainfall are expected to be positive because these variables should exert positive influence on area. Usually the signs of the coefficients of risk variables are expected to be negative, though the magnitudes of the coefficients may vary according to the extent of risks perceived by farmers on the crops grown.

2.4.4. 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 form of the estimated equation is as follows:

$$\text{Ln } At = \theta b0 + \theta b1 \ln Pt\text{-}1 + (1-\theta) \ln At\text{-}1 + \theta b2 \ln Yt\text{-}1 + \theta b3 \ln RAt + \theta b4 \ln IRt\text{-}1 + \theta b5 \ln YRt\text{-}1 + \theta b6 \ln PRt\text{-}1 + \theta \ln Vt$$

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

$\ln A_t$ 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.

2.4.5. Test of Autocorrelation

The Durbin- Watson (DW) statistic is the most popular and reliable test for detecting autocorrelation. The test is valid only if the following conditions are fulfilled: the study used a time series data, autocorrelation is of the first order, there is a constant in the equation and the equation does not include lagged values of the dependent variable as regressor. The equation all has lagged values of the dependent variable as regressor. Since the equations have lagged value of the dependent variable as regressor, a variant of DW known as Durbin h statistic is used to carry out the test (Durbin, 1970).

The test statistic is represented as:

$$h = (1 - \frac{D}{2})\sqrt{\frac{n}{(1-n) \times (var, b)}}$$

Where,

D = Computed D-W statistic, n = sample size.

Var. (b) = Variance of the coefficient of the lagged dependent variable = (standard error)$^{2.}$

3. RESULTS AND DISCUSSION

3.1. Annual Price Fluctuation and Price Trend of Rice

3.1.1 Fluctuation of Annual Prices of Aus Rice

The annual real rice price fluctuation was highly excessive in the year 1998-99 (fluctuation in positive direction). Price fluctuation of rice over 10 percent occurred in 13 years out of 30 years during the period 1981-82 to 2010-11. In period I (1980-81 to 1990-91), period II (1991-92 to 2000-01), and period III (2001-02 to 2010-11) price fluctuation of Aus rice was greater than 10 percent which prevailed in 3, 6 and 4 year respectively. In period III (2001-02 to 2010-11) range of price fluctuation was lowest among the other period (from -11.2 to 33.6 percent). Range of price fluctuation was observed to be highest in the period II (from -29.4 to 37.2 per cent). For the overall time period 1981-82 to 2010-11, the range of price fluctuation was -29.4 to 37.2 percentage which was same as the period II (1991-92 to 2000-01).

3.1.2. Fluctuation of Annual Prices of Aman Rice

Annual price fluctuation of Aman rice is shown in Table 1. The annual fluctuation of nominal price of Aman was highly excessive in 1994-95 (fluctuation in positive direction). Price fluctuation of rice over 10 percent occurred in 16 years out of 30 years during the period 1981-82 to 2010-11. In period I (1980-81 to 1990-91), period II (1991-92 to 2000-01), and period III (2001-02 to 2010-11) price fluctuation of Aman rice was greater than 10 percent which prevailed in 6, 6 and 4 year respectively.

Of the three periods, price fluctuation was the lowest (1.7 to 31.5 per cent) in sub-period and the highest (-27.0 to 40.7 per cent) in period II. Price fluctuations for the entire period (1981-82 to 2010-11) were the same as there of sub-period II. The annual real rice price of Aman fluctuation was highly excessive in the year 1996-97 (fluctuation in negative direction). Price fluctuation of rice over 10 percent occurred in 13 years out of 30 years during the period 1981-82 to 2010-11. In period I (1980-81 to 1990-91), period II (1991-92 to 2000-01), and period III (2001-02 to 2010-11) price fluctuation of Aman rice was greater than 10 percent which prevailed in 3, 6 and 4 year respectively. In period III (2001-02 to 2010-11) price fluctuation was lowest among the other period (from -2.1 to 23.5 percent). Range of price fluctuation was observed to be highest in period II (from -29.7 to 29.2 per cent). For the overall time period 1981-82 to 2010-11, the price fluctuation was -29.7 to 29.2 percentage which was same as the period II (1991-92 to 2000-01).

Table-1. Fluctuation in annual prices of aus rice.

Year	Nominal Price of Aus Rice (TK/ Quintal)	Deflated Price of Aus Rice (TK/ Quintal)	Period	Annual Fluctuation of Nominal price of Aus (%)	Annual Fluctuation of Real price of Aus (%)	Range of Annual Price Fluctuation (%)
1981-82	275	1263.47	I			-15.7 to 33.9
1982-83	359	1500.15		30.5	18.7	(Nominal Price)
1983-84	366	1396.59		1.9	-6.9	
1984-85	490	1681.36		33.9	20.4	-23.3 to 20.4
1985-86	413	1290.39		-15.7	-23.3	(Real Price
1986-87	488	1358.93		18.2	5.3	
1987-88	501	1292.38		2.7	-4.9	
1988-89	587	1396.83		17.2	8.1	
1989-90	568	1301.37		-3.2	-6.8	
1990-91	589	1245.96		3.7	-4.3	
1991-92	627	1268.46	II	6.5	1.8	-26.6 to 46.9
1992-93	586	1153.91		-6.5	-9.0	(Nominal Price)
1993-94	465	886.591		-20.6	-23.2	
1994-95	624	1092.85		34.2	23.3	-29.4 to 37.2
1995-96	692	1136.33		10.9	4.0	(Real Price)
1996-97	508	802.411		-26.6	-29.4	
1997-98	497	722.489		-2.2	-10.0	
1998-99	730	991.18		46.9	37.2	
1999-00	627	828.249		-14.1	-16.4	
2000-01	586	759.368		-6.5	-8.3	
2001-02	544	685.784	III	-7.2	-9.7	-7.2 to 50.1
2002-03	564	681.139		3.7	-0.7	(Nominal Price) -11.2 to 33.6
2003-04	720	821.621		27.7	20.6	(Real Price)
2004-05	895	959.133		24.3	16.7	
2005-06	874	874		-2.3	-8.9	
2006-07	953	871.195		9.0	-0.3	
2007-08	1430	1164.12		50.1	33.6	
2008-09	1459	1103.88		2.0	-5.2	
2009-10	1568	1110.64		7.5	0.6	
2010-11	1544	986.014		-1.5	-11.2	
Entire period of 1981-82 to 2010-11						-26.6 to 50.1 (Nominal Price) -29.4 to 37.2 (Real Price)

Source: BBS (2007).

3.1.3. Fluctuation of Annual Prices of Boro Rice

Annual fluctuation of Boro rice prices are shown in Table 2. The annual nominal rice price of Boro fluctuation was highly excessive in the years 1992-93 that was 48.5 percent (fluctuation in negative direction). Price fluctuation of rice over 10 percent occurred in 12 years out of 30 years during the entire period of the study. In period I (1980-81 to 1990-91), period II (1991-92 to 2000-01), and period III (2001-02 to 2010-11)price fluctuation of Boro rice was greater than 10 percent which prevailed in 5, 4 and 3 year respectively. In period III (2001-02 to 2010-11) price fluctuation was lowest among the other period (from 2.1 to 19.2 percent). Range of price fluctuation was observed to be highest in period II (from -48.5 to 28.5 per cent). For the overall time period 1981-82 to 2010-11, the price fluctuation was -48.5 to 28.5 percentage which was same as the period II (1991-92 to 2000-01). The fluctuation of annual real rice price of Boro was highly excessive in the year 1992-93 that was 34.4 percent (fluctuation in negative direction). Price fluctuation of rice over 10 percent occurred in 8 years out of 30 years during the period 1981-82 to 2010-11. In period I (1980-81 to 1990-91), period II (1991-92 to 2000-01), and period III (2001-02 to 2010-11) price fluctuation of Boro rice was greater than 10 percent which prevailed in 4, 3 and 1 year respectively. In period III (2001-02 to 2010-11) price fluctuation was lowest (-7.9 to 16.3 per cent) among the other periods. Range of price fluctuation was observed to be highest in sub-period II (from -34.4 to 28.4 per cent). For the overall time period 1981-82 to 2010-11, the price fluctuation was -34.4 to 28.4 percentage which was same as there of the period II (1991-92 to 2000-01) Table 3.

Table-2. Fluctuation in annual prices of Aman rice.

Year	Nominal Price of Aman Rice (TK/ Quintal)	Deflated Price of Aman Rice (TK/ Quintal)	Period	Annual Fluctuation of Nominal price of Aman (%)	Annual Fluctuation of Real price of Aman (%)	Range of Annual Price Fluctuation (%)
1981-82	353	1621.8	I			-12.3 to 31.0 (Nominal Price) -20.1 to 16.8 (Real Price)
1982-83	367	1533.6		4.0	-5.4	
1983-84	444	1694.2		21.0	10.5	
1984-85	522	1791.2		17.6	5.7	
1985-86	458	1431.0		-12.3	-20.1	
1986-87	600	1670.8		31.0	16.8	
1988-89	623	1482.5		5.8	-2.4	
1989-90	551	1262.4		-11.6	-14.8	
1990-91	632	1336.9		14.7	5.9	
1991-92	646	1306.9	II	2.2	-2.2	-27.0 to 40.7 (Nominal Price) -29.7 to 29.2 (Real Price)
1992-93	502	988.5		-22.3	-24.4	
1993-94	519	989.6		3.4	0.1	
1994-95	730	1278.5		40.7	29.2	
1995-96	764	1254.6		4.7	-1.9	
1996-97	558	881.4		-27.0	-29.7	
1998-99	890	1208.4		25.5	17.2	
1999-00	656	866.6		-26.3	-28.3	
2000-01	627	812.5		-4.4	-6.2	
2001-02	679	856.0	III	8.3	5.4	1.7 to 31.5 (Nominal Price) -2.1 to 23.5 (Real Price)
2002-03	694	838.1		2.2	-2.1	
2003-04	742	846.7		6.9	1.0	
2004-05	976	1045.9		31.5	23.5	
2005-06	993	993.0		1.7	-5.1	
2006-07	1088	994.6		9.6	0.2	
2008-09	1441	1090.3		11.2	3.3	
2009-10	1699	1203.4		17.9	10.4	
2010-11	2201	1405.6		29.5	16.8	
Entire period of 1981-82 to 2010-11						-27.0 to 40.7 (Nominal Price) -29.7 to29.2 (Real Price)

Source: BBS (2007).

3.1.4. Comparison of Annual Fluctuation of Rice Price

After measuring the annual price fluctuation of nominal and real price of all rice seasons there will be arisen such question that is what's the picture of annual price fluctuation among the rice seasons for the entire time period and which sub-period shows more price fluctuation in rice seasons (Murshid and Yunus, 2018). The method coefficient of variation was used to show the picture of the rice seasons. Sometime the fluctuation is high and some time the fluctuation is low. By using the coefficient of variation method it is seen that the price fluctuation of Boro rice was the highest relative to Aus and Aman rice for the entire period of time because the inflation rate (Ayinde *et* al., 2017). The coefficient of variation was 25.03 for Boro and 23.99 and 23.87 for the Aus and Aman rice respectively Table 4. It was observed that the CV was the lowest for the Aman rice.

Table-3. Fluctuation in annual prices of Boro rice.

Year	Nominal Price of Boro Rice (TK/Quintal)	Deflated Price of Boro Rice (TK/Quintal)	Period	Annual Fluctuation of Nominal price of Boro (%)	Annual Fluctuation of Real price of Boro (%)	Range of Annual Price Fluctuation (%)
1981-82	339	1557.51	I			-12.7 to 17.2 (Nominal Price) -17.8 to 10.7 (Real Price)
1982-83	366	1529.40		7.4	-1.8	
1983-84	442	1686.59		17.2	10.3	
1984-85	404	1386.27		-9.4	-17.8	
1985-86	445	1390.37		9.2	0.3	
1986-87	534	1487.03		16.7	7.0	
1988-89	550	1308.78		13.8	7.0	
1989-90	543	1244.09		-1.3	-4.9	
1990-91	651	1377.12		16.6	10.7	
1991-92	628	1270.49		-3.7	-7.7	
1992-93	423	832.94		-48.5	-34.4	
1993-94	467	890.40		9.4	6.9	
1994-95	653	1143.64	II	28.5	28.4	-48.5 to 28.5 (Nominal Price) -34.4 to 28.4 (Real Price)
1995-96	552	906.44		-18.3	-20.7	
1996-97	550	868.75		-0.4	-4.2	
1998-99	640	868.98		0.2	-6.5	
1999-00	599	791.26		-6.8	-8.9	
2000-01	603	781.40		0.7	-1.2	
2001-02	625	787.90	III	3.5	0.8	2.1 to 19.2 (Nominal Price) -7.9 to 16.3 (Real Price)
2002-03	642	775.34		2.6	-1.6	
2003-04	709	809.07		9.4	4.4	
2004-05	878	940.91		19.2	16.3	
2005-06	949	949.00		7.5	0.9	
2006-07	1099	1004.66		13.6	5.9	
2008-09	1301	984.34		5.6	-1.5	
2009-10	1376	974.64		5.5	-1.0	
2010-11	1405	897.25		2.1	-7.9	
Entire period of 1981-82 to 2010-11						-48.5 to 28.5 (Nominal Price) -34.4 to 28.4 (Real Price)

Source: BBS (2007).

Table-4. Comparison of annual fluctuation of real price of three rice seasons.

Rice seasons	Coefficient of variation
Aus	23.99
Aman	23.87
Boro	25.03

It was also found that CV of annual fluctuation of real price of Aus rice in the sub-period (1991/92 to 2000/01) was the highest (19.75) compared to the sub-periods (9.69) and III (18.41). The CV for the sub-periods I (1981/82 to 1990/91) and III (2001/02 to 2010/11) was 9.69 and 18.41 respectively. It also found that the annual fluctuation of real price of Aman and Boro rice were the highest for the sub-period II (1991/92 to 2000/01) compared to the sub-periods I (1981/82 to 1990/91) and III (2001/02 to 2010/11).

3.2. Estimation of Area Response of Rice in Bangladesh

This study has investigated the acreage response of all types of rice to provide an idea about all those concerned with acreage response of rice (all types), if and to what extent, a given price policy will be effective to determining the supply of rice in Bangladesh. Results of econometric estimates of supply response of all rice seasons during 1981/82 to 2010/11 using time series data with application of Nerlovian Partial Adjustment model are presented.

3.2.1. Nerlovian Supply Response Model

Responsiveness of farmers to change in area depends on the nature of their allocation decisions. There are many factors which influence the area allocation decisions of farmers. Successful agricultural needs to be based on actual observations of farmers reactions to price changes and other influencing factors such as expected yield (technological change), yield risk and price risk variables and rainfall during sowing period and irrigated area during the rice seasons (Xie and Wang, 2017). The log linear forms of equations depicted better explained results and generated direct elasticity coefficients. The equations are estimated through the Ordinary Least Square (OLS) estimators. A first order auto regressive model was used which gave better results in terms of significant coefficients and the magnitudes of coefficient to determination. The crop supply situation in developing agriculture suggests that the area allocation decisions for crop supply is influenced by lagged price, expected yield, rainfall, irrigation, price and yield risks. The relevant price and non-price variables should be specified in any econometric model to arrive at correct and unbiased magnitudes of the parameters that affect the supply of crop output (Durand-Morat *et al.*, 2018). The rice area response equation for all Varieties are specified with lagged price, lagged area, yield, rainfall, irrigation and yield and price risk. Estimated results of these equations are presented in Table 5, Table 6 and Table 7. These equations for all rice varieties area of the varieties has been used as dependent variables.

3.2.2. Area Response of Aus Rice

Aus area shows responsiveness to price changes. To arrive at a deflated price, the per quintal harvest price of Aus is divided by per quintal harvest price of Jute. Price of jute was considered in the model because it is competitive crop of Aus rice. And to avoid the multicollinearity, ratio of the Aus price to jute price was included in the model. In this model it was used the lagged area of Aus rice, the lagged yield of Aus, rainfall for the time of sowing and yield and price risk (Timsina *et al.*, 2018). Before estimate the equation we need to test the autocorrelation and multicollinearity among the variables. To test the multicollinearity, we see that there was no multicollinearity among the variable. The Durbin-Watson statistic indicates that there was no serial auto correlation. For further confirmation, the Durbin h statistic was calculated and it„s also support the evidence of no auto correlation. The result of the Durbin h test was 0.21 which lies between -1.96 to 1.96 that means there is no autocorrelation among the variable. Price elasticity of area allocation of Aus rice has appeared 0.010 i.e. one hundred per-cent increase/decrease in Aus price (relative to Jute price) in any year would increase/decrease Aus area by 1 per-cent in the following year. Long-run price elasticity of Aus was 0.217. That means if price of Aus (relative to jute price) increases 1 percent then the area cultivation of Aus would increase 0.217 percent in the following year in the long run and vice versa if other factors held constant. The coefficient of the lagged area variable was highly significant in the Aus area response equation presented in Table 5. That implies that last year's area allocation of Aus rice has a positive significant influence on area allocation for the following year.

Table-5. Aus area response to price and non-price factors (1981/82- 2010/11).

Price	Model	Estimator	Coefficients of	Coefficient

variable	type		Constant	lnP_{t-1}	lnA_{t-1}	lnY_{t-1}	$lnRA_t$	$lnYR_{t-1}$	$lnPR_{t-1}$	
Aus harvest price to Jute harvest price ratio	Partial Adjustment	OLS	-0.015 (-0.008)	0.010 (0.122)	0.954*** (10.409)	0.034 (0.184)	0.029* (0.901)	-0.016 (0.685)	0.014 (0.623)	0.046
R^2= 0.971; Adjusted R Square = 0.962; F = 111.676; D-W = 1.933; Durbin h statistic = 0.21										

Note: variable prefixing ln is in natural logarithms. Subscript "t" stands for current variables. Parenthesized Figure shows the t ratio. OLS – Ordinary Least Square, Significant at 1% level **Significant at 5% level *Significant at 10% level.

Table-6. Coefficient of adjustment and Short-run and Long-run price elasticity of Aus rice.

Coefficient of adjustment	Short-run elasticity	Long-run elasticity
0.046	0.010	0.217

Where,

lnP_{t-1} – Aus harvest price to Jute price ratio, price variable lagged by one year.

lnA_{t-1} - Area variable lagged by one period. This variable is included in the equation as a requirement for the Nerlovian model.

lnY_{t-1} - Yield during the current period on the yield trend of preceding two years.

$lnRA_t$ - Rainfall during the planting period in millimeter. For Aus rice March, April and May rainfall is used.

$lnYR_t$ – Coefficient of variation of yields based on preceding three years' average yield.

$lnPR_{t-1}$ - Coefficient of variation of price based on preceding three years' average price.

The value of coefficient of area adjustment was 0.954, that's means last year areas cultivation of Aus increase 1 percent then the areas cultivation of Aus would increase 0.954 percent in the following year and vice versa if other things held constant. Area response to expected rice yield (preceding two years' average yields) depends on the types of rice and seasons grown. Area may decrease even with increasing average yield or may increase depending on the relative role or the rice type to all substances requirements and interaction with price and non-price variables e.g. access to flood measures, varietal development of substitutable crop(s). In this model expected yield implies that there is no influence on the area allocation of Aus rice because the yield has a positive sign but statistically insignificant result (Timsina *et al.*, 2018).

Aus are not an irrigated crop. Rainfall during March, April and May has been playing a crucial and significant role in area allocation of Aus rice. Sowing period rainfall came out significant in Aus area response by using this model. The short-run rainfall elasticity is 0.029. An increase of one percent rainfall up to the optimum level rainfall would increase Aus area 2.9 percent. Yield and price risk variables are very important for a better understanding of the farmer's behavioral pattern about area allocation of Aus rice. Incorporation of yield and price risk variable into the Aus area response equation improved the R^2 value and increase the number of significant variables with improvement in magnitudes of the "t" ratios. Yield and price risk variables are measured in terms of coefficient of variation of the preceding three years' average yield and harvest price of Aus rice. Both the yield and price risk for Aus rice was insignificant but the sign of the yield risk is negative that's means farmers averse response to year fluctuation if variability is low they allocate more areas to Aus rice. The coefficients of multiple determinations (R^2) were found 97 percent which indicate that the fitted equations explained 97 percent of the variation in the allocation of area for Aus rice production. The F-test was used to measure the overall significance of the estimated regression, which was found significant at 1 percent level.

3.2.3. Area Response of Aman Rice

For Aman area response, Nerlovian partial adjustment model was also used. Aman area response results are presented in Table 7 and Table 8. First the proper specification of variable is considered to be which is efficient for estimating short run elasticity. Aman area shows responsiveness to price changes. To arrive at a deflated price, the per quintal harvest price of Aman is divided by consumer price index. In this model we also used the lagged area of Aman rice, the expected yield of Aman, irrigated area for Aman season and yield and price risk. Before estimate the equation we need to test the autocorrelation and multicollinearity among the variables. After test the multicollinearity we see that there was no multicollinearity among the variable. The Durbin-Watson statistic indicates that there is no serial auto correlation. For further confirmation, the Durbin h statistic was calculated and it also support the evidence of no auto correlation. The result of the Durbin h test was 0.26 which lies between -1.96 to 1.96 that means there is no autocorrelation among the variable in Aman rice response equation. Price elasticity of area allocation of Aman rice has appeared 0.091 i.e. one hundred per-cent increase/decrease in Aman price (deflated price) in any year would increase/decrease Aman area by 9.1 per-cent in the following year. Long-run price elasticity of Aman was 11.2 percent.

Table-7. Aman area response to price and non-price factors (1981/82- 2010/11).

Price variable	Model type	Estimator	Coefficients of							Coefficient of adjustment
			Constant	lnP_{t-1}	lnA_{t-1}	lnY_{t-1}	$lnRA_t$	$lnYR_{t-1}$	$lnPR_{t-1}$	
Deflated price	Partial Adjustment	OLS	5.684 (2.039)	0.091 (1.541)	0.194 (0.876)	0.291* (1.768)	-0.087* (-1.880)	-0.003 (-0.194)	0.021 (0.162)	0.806
R^2 = 0.299; Adjusted R Square = 0.089; F = 1.42; D-W = 1.923; D-W h statistic= 0.266										

Note: variable prefixing ln is in natural logarithms. Subscript "t" stands for current variables. Parenthesized Figure shows the t ratio. OLS – Ordinary Least Square.

Table-8. Coefficient of adjustment and short-run and long-run price elasticities of aman rice.

Coefficient of adjustment	Short-run elasticity	Long-run elasticity
0.806	0.091	0.112

Where,

lnP_{t-1} – Harvest price deflated by consumer price index. Deflated Aman price variable lagged by one period has been used.

lnA_{t-1} – Area variable lagged by one period. This variable is included in the equation as a requirement for the Nerlovian model.

lnY_{t-1} - Yield during the current period on the yield trend of preceding two years.

$lnIR_t$ – Irrigated area of rice in thousand acre during the Aman seasons.

$lnYR_t$ – Coefficient of variation of yields based on preceding three years yield.

$lnPR_{t-1}$ - Coefficient of variation of price based on preceding three years price.

Area response to expected rice yield (preceding two years average yields) depends on the types of rice and seasons grown. Irrigation is held on the Aman season, there has a lot of cultivated area under the irrigation system because amount of rainfall is uncertain. Some year there has excess rainfall and some year there have less rainfall. Irrigated area in Aman rice season was significant but had a negative influence on the area allocation of the Aman rice. Because if the amount of irrigated area increase the cultivated area under the Aman season decrease. The coefficient was -0.087 which implies that one hundred percent increase in irrigated area in previous year would decrease 8.7 percent of Aman area in the following year. The coefficients of multiple determinations (R^2) were found from 29 percent which indicate that the fitted equations explained about only 29 percent of the variation in the allocation of area for Aman rice production. The F-test was used to measure the overall significance of the estimated regression, which was found insignificant.

3.2.4. Area Response of Boro Rice

For estimation of acreage response of Boro rice Nerlovian partial adjustment model was also used. The results of acreage response of Boro rice are presented in Table 9 and Table 10.

Table-9. Boro area response to price and non-price factors (1981/82- 2010/11).

Price variable	Model type	Estimator	Coefficients of						Coefficient of adjustment
			Constant	lnP_{t-1}	lnA_{t-1}	lnY_{t-1}	$lnYR_{t-1}$	$lnPR_{t-1}$	
Boro harvest price to Wheat Harvest price ratio	Partial Adjustment	OLS	0.287 (.304)	0.051 (0.610)	0.871*** (10.726)	0.082 (0.356)	-0.017 (-0.641)	0.003 (0.134)	0.129
R^2 = 0.974; Adjusted R Square = 0.968; F = 156.139; D-W = 1.54; D h statistic = 1.408									

Note: variable prefixing ln is in natural logarithms. Subscript "t" stands for current variables. Parenthesized Figure shows the t ratio. OLS – Ordinary Least Square.

Table-10. Coefficient of adjustment and short-run and long-run price elasticity of boro rice.

Coefficient of adjustment	Short-run elasticity	Long-run elasticity
0.129	0.051	0.395

Where,

lnP_{t-1}– Boro harvest price to Wheat price ratio, price variable lagged by one year.

lnA_{t-1}– Area variable lagged by one period. This variable is included in the equation as a requirement for the Nerlovian model.

lnY_{t-1}- Yield during the current period on the yield trend of preceding two years.

$lnYR_t$ – Coefficient of variation of yields based on preceding three years average yield.

$lnPR_{t-1}$- Coefficient of variation of price based on preceding three years average price.

First, the proper specification of variable is considered which is efficient for estimating short run elasticity of Boro rice and direction of change. Since lagged dependent variable appears in case of Boro acreage response function, it implies partial adjustment to relative price level changes within the year (Murshid and Yunus, 2018). In the estimated response function, price variable was taken as the ratio of Boro price to wheat price. In this model we also used the lagged area of Boro rice, the expected yield of Boro, and yield and price risk. Before estimate the equation we need to test the auto correlation and multicollinearity among the variables. After test the multicollinearity we see that there was no multicollinearity among the variable. The Durbin- h static test also used to measure the autocorrelation. The Durbin-Watson statistic indicates that there is no serial auto correlation. For further confirmation, the Durbin h statistic was calculated and it also supports the evidence of no auto correlation (Shew *et al.*, 2019).

The result of the D-W h test was 1.40 which lies between -1.96 to 1.96 that means there is no autocorrelation among the variable in Boro rice response equation. Price elasticity of area allocation of Boro rice had appeared 0.051 i.e. one hundred per-cent increase/decrease in Boro price (deflated price) in any year would increase/decrease Boro area by 1 per-cent in the following year. Long-run price elasticity of Boro was 39.5 percent. The coefficient of the lagged area variable was highly significant in the Boro area response equation presented in Table 5. The value of the coefficient is 0.871 that's implies that if last year's area allocation of Boro rice increases one percent then the area allocation of Bororice also increases 0.871 percent in the current year and vice versa if other factors held constant. It has a positive influence on area allocation for current year. The lagged yield variable turned out positive but insignificant for the Boro rice area. Yield and price risk variables are also very important for a better understanding of the farmer's behavioral pattern about area allocation of Boro rice. Incorporation of yield and price risk variable into the Boro area response equation improved the R^2 value with improvement in magnitudes of the 't' ratios.

The coefficient of multiple determinations (R^2) was found 97 percent which indicate that the fitted equations explained about 97 percent of the variation in the allocation of area for Boro rice production. The F-test was used to measure the overall significance of the estimated regression, which was found significant at 1 percent level. The study investigated area responses in terms of price with other non-price factors. The response results revealed that the most important determinants of area allocation to Aus and Boro was the lagged area of Aus and Boro which is highly significant and positive influence on current year area allocation of Aus and Boro. In the Aus season rainfall have a positive influence to allocate area for the current year. Acreage response of Aman shows that yield have a positive influence on area allocation of Aman and the amount of irrigated area has a negative influence on the area allocation of Aman rice. Researchers, policy planners may use this result to help farmers take better decision in terms of are allocation for all the rice varieties.

4. CONCLUSION

The focus of the study was to determine price fluctuation for comparing price situation in different periods and estimating price trend of rice crops 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. Fluctuation in rice prices has a great economic impact on the people of Bangladesh. During the study period of 1981-82 to 2010-11 rice price fluctuated to a great extent. The nominal Aus rice price fluctuation was highest in the sub-period II. The extent of annual fluctuation was found to be highest for real price of the sub-period II followed by sub-period I and sub-period III. That means in sub-period II the country faced the highest volatile Aus price though its average real prices of Aus remained more or less stable. The nominal Aman rice price fluctuation was highest in the sub-period II. The extent of annual fluctuation was found to be highest for real price of Aman of the sub-period II followed by sub-period I and sub-period III. Again the nominal Boro rice price fluctuation was also highest in the sub-period II. The extent of annual fluctuation was found to be highest for Boro real price of the sub-period II followed by sub-period I and sub-period III. It was found that annual rice price in the sub-period I and sub-period III was more stable compare with the sub-period II.

To analyze the acreage response, the study covered the time period of 1981/82 to 2010/11. Nerlovian Partial adjustment model was used for estimating the acreage response of rice crop in Bangladesh. Nerlovian acreage response model appeared superior in explaining the farmer's decision about area allocation of rice (all seasons). Lagged price, lagged area, expected yield, rainfall, irrigation, yield and price risk variables were used to estimate the acreage response of rice crop. The Ordinary Least Square (OLS) methods were used to estimate the acreage response of rice. The price variables are insignificant for all the rice seasons. Short run price allocation of Aus has appeared 0.010 i.e. one hundred per-cent increase/decrease in Aus price (relative to Jute price) in any year would increase/decrease Aus area by 1 per-cent in the following year. Long-run price elasticity of Aus was 0.21. It implies that there has a low effect of Aus price on the area allocation of Aus rice. Short-run price elasticity of Aman rice has appeared 0.091 i.e. one hundred per-cent increase/decrease in Aman price (deflated price) in any year would increase/decrease Aman area by 9.1 per-cent in the following year. Long-run price elasticity of Aman was 0.112 and short-run price elasticity of Boro rice has appeared 0.051 i.e. one hundred per-cent increase/decrease in Boro price (deflated price) in any year would increase/decrease Boro area by 5.1 per-cent in the following year. Long-run price elasticity of Boro was 0.395. The irrigated area has a negative influence on the area allocation of Aman rice. The yield risk gave negative sign for all rice seasons and price risk gave positive sign and both are turned out insignificant. The findings indicate that the implementation of a price support policy could be used to adjustment of area of rice in Bangladesh. If the government would follow some policy, it would reduce risk in rice production and produce a positive impact on the area adjustment of rice. If the government would follow a price stabilization policy, it would reduce price risk and would produce a positive impact on crop supply situation in Bangladesh.

REFERENCES

Alam, G.M.M., K. Alam, S. Mushtaq, M.N.I. Sarker and M. Hossain, 2019. Hazards, food insecurity and human displacement in rural riverine Bangladesh: Implications for policy. International Journal of Disaster Risk Reduction, 41(12): 1–27.

Alam, G.M.M., M.N. Khatun and M.N.I. Sarker, 2019. Vulnerability to food security due to riverbank erosion in Bangladesh. In M. Hossain, Q. K. Ahmad, & M. Islam (Eds.), Climate Adaptation for a Sustainable Economy: Lessons from Bangladesh, an Emerging Tiger of Asia. Hauppauge, NY, 11788 USA: Nova Science Publishers. pp: 1–20.

Ayinde, O.E., D.A. Bessler and F.E. Oni, 2017. Analysis of supply response and price risk on rice production in Nigeria. Journal of Agribusiness and Rural Development, 16(1): 17–24.Available at: https://doi.org/10.17306/j.jard.2017.00279.

Barmon, B.K. and M. Chaudhury, 2012. Impact of price and price variability on acreage allocation in rice and wheat production in Bangladesh. The Agriculturists, 10(1): 23-30.Available at: https://doi.org/10.3329/agric.v10i1.11061.

BBS, 2007. Statistical pocket book Bangladesh 2017. Dhaka, Bangladesh: Bangladesh Bureau of Statistics.

Cao, Q., M.N.I. Sarker and J. Sun, 2019. Model of the influencing factors of the withdrawal from rural homesteads in China: Application of grounded theory method. Land Use Policy, 85: 285-289.Available at: https://doi.org/10.1016/j.landusepol.2019.04.013.

Chowdhury, N.T., 2013. Marginal product of irrigation expenses in Bangladesh. Water Resources and Economics, 4: 38-51.Available at: https://doi.org/10.1016/j.wre.2013.11.002.

Durand-Morat, A., L.L. Nalley and G. Thoma, 2018. The implications of red rice on food security. Global Food Security, 18: 62-75.Available at: https://doi.org/10.1016/j.gfs.2018.08.004.

Durbin, J., 1970. Testing for serial correlation in least-squares regression when some of the regressors are lagged dependent variables. Econometrica (pre-1986), 38(3): 410-421.Available at: https://doi.org/10.2307/1909547.

Haile, M.G., M. Kalkuhl and J. von Braun, 2015. Worldwide acreage and yield response to international price change and volatility: A dynamic panel data analysis for wheat, rice, corn, and soybeans. American Journal of Agricultural Economics, 98(1): 172-190.Available at: https://doi.org/10.1093/ajae/aav013.

Islam, M.S., M.A. Ali and M.N.I. Sarker, 2015a. Efficacy of medicinal plants against seed borne fungi of wheat seeds. International Journal of Natural and Social Sciences, 2(21): 48-52.

Islam, M.S., R. Proshad, H.M. Asadul, F. Hoque, M.S. Hossin and M.N.I. Sarker, 2018. Assessment of heavy metals in foods around the industrial areas: Health hazard inference in Bangladesh. Geocarto International, 33(9): 1016-1045.Available at: https://doi.org/10.1080/10106049.2018.1516246.

Islam, M.S., M.N.I. Sarker and M.A. Ali, 2015b. Effect of seed borne fungi on germinating wheat seed and their treatment with chemicals. International Journal of Natural and Social Sciences, 2(1): 28-32.

Karim, M.M., M.S. Raha, S.K. Barua and S. Farid, 2016. Price instability and the spatial price relationship of rice in some selected rice markets of Bangladesh. International Journal of Development and Sustainability, 5(6): 267–277.

Murshid, K.A.S. and M. Yunus, 2018. Rice prices and growth, and poverty reduction in Bangladesh. Rome, Italy: Food and Agriculture Organization.

Nasrin, M., M.N.I. Sarker and N. Huda, 2019. Determinants of health care seeking behavior of pregnant slums dwellers in Bangladesh. Medical Science, 23(95): 35–41.

Prodhan, A., M.N.I. Sarker, A. Sultana and M. Islam, 2017. Knowledge, adoption and attitude on banana cultivation technology of the banana growers of Bangladesh. International Journal of Horticultural Science and Ornamental Plants, 3(1): 47-52.

Sarker, M.N.I., 2016a. Poverty of Island Char dwellers in Bangladesh. Germany: Hamburg, Diplomica Publishing GmbH.

Sarker, M.N.I., 2016b. Role of banks on agricultural development in Bangladesh. International Journal of Ecology and Development Research, 1(1): 10–15.

Sarker, M.N.I., 2019a. Administrative resilience: Potential approach for disaster management. In A. Farazmand (Ed.), Global Encyclopedia ofPublic Administration, Public Policy, and Governance. Switzerland AG: Springer Nature. pp: 1-5.

Sarker, M.N.I., 2019b. Instrumentally rationalizing public administration. In A. Farazmand (Ed.), Global Encyclopedia of Public Administration, Public Policy, and Governance. Switzerland AG: Springer Nature. pp: 1-5.

Sarker, M.N.I., M.A. Ali and M.S. Islam, 2015. Causes and possible solutions of poverty perceived by char dwellers in Bangladesh. International Journal of Natural and Social Sciences, 2(1): 37-41.

Sarker, M.N.I., S.C. Barman, M. Islam, R. Islam and A.S. Chakma, 2017. Role of lemon (Citrus limon) production on livelihoods of rural people in Bangladesh. Journal of Agricultural Economics and Rural Development, 3(1): 167-175.

Sarker, M.N.I., Y. Bingxin, A. Sultana and A. Prodhan, 2017. Problems and challenges of public administration in Bangladesh: Pathway to sustainable development. International Journal of Public Administration and Policy Research, 2(1): 008-015.

Sarker, M.N.I., Q. Cao, M. Wu, M.A. Hossin, G.M. Alam and R.C. Shouse, 2019. Vulnerability and livelihood resilience in the face of natural disaster : A critical conceptual review. Applied Ecology and Environmental Research, 17(6): 12769–12785.Available at: https://doi.org/10.15666/aeer/1706_1276912785.

Sarker, M.N.I., M.S. Islam, M.A. Ali, M.S. Islam, M.A. Salam and S.H. Mahmud, 2019. Promoting digital agriculture through big data for sustainable farm management. International Journal of Innovation and Applied Studies, 25(4): 1235-1240.

Sarker, M.N.I. and Z. Jie, 2017. Social security for vulnerable groups in Bangladesh on government perspective: Contribution of research leader. Journal of Public Policy and Administration, 1(1): 1-9.

Sarker, M.N.I., M.Z. Rahman, Q. Cao and Z. Xu, 2019. Impact of small entrepreneurship on poverty alleviation and sustainable livelihood of street vendors. International Journal of Innovation and Applied Studies, 25(4): 1241-1254.

Sarker, M.N.I. and A. Sultana, 2017. An investigation into the status of Riverbank (Char) women dwellers in Bangladesh. International Journal of Rural Development, Environment and Health Research, 1(1): 86-92.

Sarker, M.N.I., M. Wu, G. Alam and R.C. Shouse, 2019. Livelihood vulnerability of Riverine-Island Dwellers in the face of natural disasters in Bangladesh. Sustainability, 11(6): 1-23.Available at: https://doi.org/10.3390/su11061623.

Sarker, M.N.I., M. Wu, G.M. Alam and M.S. Islam, 2019. Role of climate smart agriculture in promoting sustainable agriculture: A systematic literature review. International Journal of Agricultural Resources Governance and Ecology, 15(2): 1–15.

Sarker, M.N.I., M. Wu, B. Chanthamith, S. Yusufzada, D. Li and J. Zhang, 2019. Big data driven smart agriculture: Pathway for sustainable development. 2019 2nd International Conference on Artificial Intelligence and Big Data (ICAIBD). IEEE. pp: 60-65.

Sarker, M.N.I., M. Wu, R. Liu and C. Ma, 2019. Challenges and opportunities for information resource management for E-governance in Bangladesh. In J. Xu et al. (Ed.), Proceedings ofthe Twelfth International Conference on Management Science and Engineering Management: Lecture Notes on Multidisciplinary Industrial Engineering. Springer International Publishing. pp: 675-688.

Sarker, M.N.I., M. Wu, R.C. Shouse and C. Ma, 2019. Administrative resilience and adaptive capacity of administrative system: A critical conceptual review. International Conference on Management Science and Engineering Management. Springer, Cham. pp: 717-729.

Shew, A.M., A. Durand-Morat, B. Putman, L.L. Nalley and A. Ghosh, 2019. Rice intensification in Bangladesh improves economic and environmental welfare. Environmental Science & Policy, 95: 46-57.Available at: https://doi.org/10.1016/j.envsci.2019.02.004.

Timsina, J., J. Wolf, N. Guilpart, L. Van Bussel, P. Grassini, J. Van Wart, A. Hossain, H. Rashid, S. Islam and M. Van Ittersum, 2018. Can Bangladesh produce enough cereals to meet future demand? Agricultural Systems, 163: 36-44.Available at: https://doi.org/10.1016/j.agsy.2016.11.003.

Xie, H. and B. Wang, 2017. An empirical analysis of the impact of agricultural product price fluctuations on China's grain yield. Sustainability, 9(6): 1–14.Available at: https://doi.org/10.3390/su9060906.

Yap, C.L., 1997. Price instability in the international rice market: Its impact on production and farm prices. Development Policy Review, 15(3): 251-276.Available at: https://doi.org/10.1111/1467-7679.00035.