Impact of Shifting Food Grain Production System on Agricultural Economy of Bangladesh

Dr. M. Sayedur Rahman

Abstract

Climate variability is a powerful physical feature of Bangladesh. It has large impacts both positive and negative on agriculture. This study aims at understanding and analyzing the role, impact and issues related to demand of food grain production system in Bangladesh. It seeks to examine both positive and negative aspects of the food grain production system and its requirements. The spatial distribution of food grain data have come from 64 districts of the year 2000. They have been collected from Bangladesh Bureau of Statistics and Food Planning Monitoring Unit, Ministry of Food. The data have been reduced in different form and finally used in the multiple regression models. The statistical software SPSS) has been used in the analysis. Bangladesh's economy depends on agriculture. Production and marketing together contribute about 50 percent share of the GDP. Poverty is the major determinant of food insecurity. The fitted regression model shows that Aus, Aman, Boro and Wheat production has positive impact on surplus-deficit whereas food grain requirement has negative impact on surplus-deficit. This study will help identify the policies needed for the development of competitive and efficient agricultural markets that could contribute towards reducing rural poverty and promoting agricultural economic growth in the country.

Key Words: Food grain, spatial distribution, multiple regression, surplus-deficit.

1. Introduction

The economy of Bangladesh is based on agriculture. The agriculture sector contributes about 32% of GDP. A wide variety of crops are grown in the country in different crop seasons. There are two broadly classified crop seasons in Bangladesh, namely summer (kharif) and winter (rabi). The summer season starts in March and continues up to October while rabi season starts in October and continues up to March. Kharif season is further sub-divided into early kharif (March to August) and late kharif (July to October). Rice is the most dominant cereal crop, the most important food grain that is grown in all crop seasons throughout the year. The different rice crops are named according to the growing season.

The rice growing seasons are Aus, Aman and Boro. Wheat is another important cereal crop and an important component of food grains in Bangladesh. By social and cultural traditions, rice and wheat constitute the staple food crops of the country. The status of food production, and in particular food self-sufficiency, is primarily determined by how much rice and wheat in total are produced in a year compared to total requirement of food grains. The land use scenario shows that the total land area of Bangladesh is about 36.67 millions acres. Agriculture is moderately intensive with a present cropping intensity of 185%. The land use pattern for crop production in Bangladesh shows that rice is grown in 74% of the total cropped area that is Aus (15.25%), Aman (56.6%), Boro (28.15%) where harvesting time is early summer, early winter and spring respectively. Whereas wheat is covered only 5.72% of the total crop area and the harvest time is Spring (BBS, 1998).

Global warming is the result of increased human activities. Changes in agricultural conditions have impact on agricultural lands and affect farm land ecosystems. (Ohsawa et al., 1998).

Marketing plays an important role in modernizing agriculture. Inadequate marketing facilities, imperfect market structure, inefficient marketing systems and inappropriate marketing policies hinder the process of modernization and the acceleration of growth (Majiruddin, 1989). One of the reasons for the relatively slow growth in foodgrain production in Bangladesh is perhaps due to the lack of adequate and efficient marketing facilities at different levels. The marketed surplus of rice is now about 50% of production, compared with about 12% in the mid-1960s. Food policy reforms are expected to contribute to more competition and market development (Ahmed and Goletti, 1997).

Agriculture is highly dependent on the spatial and temporal distribution of monsoon rainfall. These issues need an overall study of the foodgrain marketing system in Bangladesh. In part, the large increase in marketed production is due to the expansion of Boro HYV paddy, which is harvested at the start of the monsoon season in May and June, and is thus difficult to store. About two-thirds of total farm sales take place at the farm level, rather than in the nearby markets. For small farmers, sales at the farm gate are especially common in regions with surplus per capita food grain production and / or high use of modern agricultural inputs (Chowdhury, 1992). On the whole the marketing chain plays an important role in transferring foodgrain from surplus to deficit areas and in determining prices in different markets. The distribution of a food grain in each area depends on the completion of its life cycle including organization, development and reproduction.

2. Materials and Methods

In the multiple regression model $Y = X\beta + \varepsilon$ (1)

- Y is a vector of responses
- β is a vector of parameters
- X is a matrix of constants
- ε is a vector of independent normal random variables

The assumptions concerning ε are that $E\{\varepsilon\} = 0$ and the variance-covariance matrix $\sigma^2\{\varepsilon\} = E\{\varepsilon\varepsilon'\} = \sigma^2 I$. where ,

$$\mathbf{Y} = \begin{pmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{pmatrix}, \quad \beta = \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{pmatrix}, \quad \varepsilon = \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix}$$

and

$$\mathbf{x} = \begin{pmatrix} 1 & x_{1,1} & x_{1,2} & \cdots & x_{1,k} \\ 1 & x_{2,1} & x_{2,2} & \cdots & x_{2,k} \\ \vdots & \vdots & \vdots & & \vdots \\ 1 & x_{n,1} & x_{n,2} & \cdots & x_{n,k} \end{pmatrix}, \tag{2}$$

It can be shown that the vector $\hat{\beta}$ of least squares estimates of β is given by

$$\hat{\beta} = (\mathbf{x}^T \mathbf{x})^{-1} \mathbf{x}^T \mathbf{y},$$

where $\mathbf{y}$ is the vector of observed response variables, and where the superscripts T and -1 denote *transposed* and *inverse* matrices, respectively.

The transpose of an $n \times k$ matrix $\mathbf{a}$, is a $k \times n$ matrix $\mathbf{a}^T$ which has as rows, the *columns* of $\mathbf{a}$(or, equivalently, as columns the *rows* of $\mathbf{a}$). The inverse of an $n \times n$ matrix $\mathbf{a}$ is an $n \times n$ matrix $\mathbf{a}^{-1}$ which has the property that

$$\mathbf{a}^{-1}\mathbf{a} = \mathbf{a}\mathbf{a}^{-1} = \mathbf{I}_n = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ 0 & 1 & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & 1 \end{pmatrix},$$

where $\mathbf{I}_n$ is the $n \times n$ identity matrix-if such a matrix $\mathbf{a}^{-1}$ exists. If it exists, then $\mathbf{a}$ is called invertible.

Multiple Linear Regression

The spatial distributions of food grain data were obtained from 64 districts of the year 2000. Data were obtained from Bangladesh Bureau of Statistics and Food Planning Monitoring Unit, Ministry of Food. The data were reduced in different form and finally used in the multiple regression models. The statistical software SPSS has been used in the analysis. A backward stepwise regression procedure was followed to ensure selection of the most appropriate variables in the model (Motgomery and Peck,1982).

The multiple regression model was specified as:

$$\mathbf{Y_i} = \beta_0 + \sum_{i=1}^{n}\sum_{j=1}^{k} \beta_j \mathbf{X_{ij}} + \mathbf{u_i} \qquad (3)$$

Where Y is the surplus-deficit, X is the jth independent variables like Aus rice, Aman rice, Boro rice, All rice grain, Wheat, All Food Grain, Net Food Grain Production, Mid-year Population, Food Grain Requirement. β is the coefficient of the relevant variable, β_o is the constant and u_i is the disturbance term. The explicit formulation of the multiple regression models was:

$$Y = \beta_0 + \beta_1 \text{AUS} + \beta_2 \text{AMAN} + \beta_3 \text{BORO} + \beta_4 \text{ALL\_RICE} + \beta_5 \text{WHEAT} + \beta_6 \text{ALL\_FG} + \beta_7 \text{NFG\_PROD} + \beta_8 \text{Mid-yrpop} + \beta_9 \text{FG\_REQ} + e \quad (4)$$

Where,Y= SUR_DEF = surplus-deficit, AUS = Aus rice, AMAN =Aman rice, BORO=Boro rice, ALL_RICE = All rice grain, WHEAT = Wheat, ALL_FG = All Food Grain, NFG_PROD =Net Food Grain Production, Mid-yrpop = Mid-year Population, FG_REQ = Food Grain Requirement, e= Stochastic term.

The method of least squares used to estimate the regression coefficients by SPSS software. The multiple regression model was used surplus-deficit considered as a dependent variables and independent variables considered as Aus rice, Aman rice, Boro rice, All rice grain, Wheat, All Food Grain, Net Food Grain Production, Mid-year Population, Food Grain Requirement.

2.1 Regression Diagnostics

6.1 Autocorrelation

In linear regression, it is a common practice to use the ordinary least squares residuals as estimates of the true random disturbances. It is well-known that in many circumstances these OLS residuals are not good estimates of the true disturbances (Devies et al, 2004). One of the fundamental assumptions in linear regression is that the error terms ε has mean zero, constant variance and are uncorrelated for purpose of testing hypothesis and construction of normality, so that the u are NID $(0,\sigma^2)$. Usually, the errors in time series data exhibit serial correlation (Box and Jenkins, 1976). Hampel et al. (1986) claimed that a routine data set typically contains 5%-10% outliers and even high quality data cannot be guaranteed free from it.

2.1.1 Test of Autocorrelation

Since most regression problems involving time series data exhibit positive autocorrelation, the hypothesis usually considered in the Durbin-Watson (Durbin and Watson, 1971) test are as follows :

H_o : $\rho=0$

H_1 : $\rho>0$ ....(5)

The test statistic is

$$d=\sum_{i=2}^{n} (e_i - e_{i-1})^2 / \sum_{i=1}^{n} e_i^2 \quad \text{............ (6)}$$

Where e_i, i= 1,2 ....n, are the residuals from an ordinary least square analysis applied to the data. Durbin and Watson (1971) show that d lies between two bounds, say d_L and d_U, such that if d is outside these limits a conclusion regarding the hypothesis in equ (5) can be reached.

The decision rules are if:

$d < d_L$, reject Ho: $\rho=0$

$d > d_U$, do not reject Ho: $\rho=0$

$d_L \leq d \leq d_U$ the test is inconclusive

2.2 Variable Selection by Backward Elimination Method

In multiple regression analysis certain tests of hypothesis about the model parameters are useful in measuring model adequacy (Draper and Smith, 1981). The test of significance of regression is a test to determine if there is a linear relationship between response variable and any of the regressor variables. The partial F-test, which is equivalent to t-test plays major role in model building; that is, in searching for the best set of regressors to be used in the model. Backward elimination attempts to find good model by working in the opposite direction. That is we begin with a model that includes all K as regressors. Then the partial F-statistic is computed for each regressor as if it were the last variable to enter the model. Backward elimination is often a very good variable selection procedure (Allen, 1974; Hocking, 1976).

3 Impacts on the Agriculture

Bangladesh is a food deficit country according to the scenario of domestic availability. The food grain supply consists of domestic production of food grains, foodstuff import including food aid. The extent of food deficit on an average is 10% of the total requirement, where market plays a crucial role because of regional disparity in food production and the main participant in the food grain import. In case of food-import, private sector with its increasing participation has been playing a dominant role (Rahman et. el., 2004).

A number of studies have analyzed the impacts of climate change on agricultural crops, mainly rice, in Bangladesh. The estimated impacts on rice yield varied between 6% to 14% depending on the climate change scenario (Rosenzweig and Iglesias, 1994). Karim et al. (1996) found that impacts on rice yields vary significantly across various locations, higher temperatures have negative influence on rice yields in all seasons and almost all locations, the net effect of temperature and carbon fertilization is negative on rice yields. In addition, Bangladesh is vulnerable to many environmental extremes such as floods, cyclones and storm surges. Agricultural production from Bangladesh has been severely affected due to floods over the years. For example, on average during the period 1962-1988, Bangladesh lost annually about 0.5 million tones of rice- about 30% of the country's average annual food grain imports- as a result of floods (Paul and Rashid, 1993).

Bangladesh is very prone to flooding because of its location at the confluence of the Ganges, Brahmaputra and Meghna rivers and because of the hydro-meteorological and topographical characteristics of the basins. On an average, annual floods inundate 20.5% area of the country and this can sometimes be as high as about 70% during an extreme flood event. Floods cause serious damage to the economy of Bangladesh. Global warming caused by the enhanced greenhouse effect is likely to have significant effects on the hydrology and water resources of the river basins and might ultimately lead to more serious floods in Bangladesh (Mirza, 2002).

Bangladesh is frequently visited by natural disasters such as tropical cyclones, storm surges, floods, droughts and tornadoes. A rise of temperature is likely to change cyclone incidence: cyclone intensity, if not cyclone frequency, may increase. As a result, storm surges may also increase substantially. A sea-level rise, increase in cyclone intensity and consequent increases in storm surge heights will have disastrous effects on a deltaic country like Bangladesh, which is not much above the mean sea-level (Ali, 1996; 1999).

Rahman et al. (2005) found that climate factor is playing an important role for yield and production level of the Aus rice crop. The yields of Aus rice varied from stage to stage of crop growth and varying in different location. Global warming might affect not only food grain production but also the distribution system. Bangladesh could face a catastrophic situation if rise of one meter in the sea level, including permanent inundation of about 15% to 18% of its low-lying coastal areas, loss of the Sunderbans, displacement of over 10 million people, and loss of valuable agricultural land (Al-Farouq and Huq, 1996).

Soil erosion has become a serious problem in Bangladesh. Because of high rainfall, low organic matter content of the soil, poor soil structure, poor soil management and steep slopes in the hill areas, the surface soils are being continuously washed away. In addition, there will be increased pressure on agricultural production through environmental factors. The environmental influence on crop production includes soil erosion, salinity and water logging which tend to either diminish or destroy the biological potential of land for crop production. Bangladesh needs to develop a comprehensive crop production policy with appropriate strategies to face the challenges of continuing population growth i.e. increased food grain consumption demand vis-à-vis a limited crop production area and increasing environmental problems of agricultural land (Task Force Report, 1991).

The spatial distribution of food grain is primarily controlled by temperature, warming appears to induce an upward shift in vegetation along each topographic unit. For a more accurate prediction of warming effects, it is necessary to identify topographic factors controlling the distribution of plant species as well as climatic factors (Ohsawa et al., 1998).

Bangladesh agriculture depends on weather conditions. Good weather conditions lead to good harvest and unfavorable weather condition causes poor harvest. Moreover, physical increase of food grain production does not ensure availability of food to the food insecure fractions of the population, in particular the disadvantaged vulnerable groups. The food grain production has not yet reached sustainable level and there have been ups and downs in production level in the last decade. The food grain production scenario in Bangladesh suffers from great instability. Therefore, sustainability in crop production has now become an important challenge.

4. Results and Discussions

Agricultural produces are the lifeline of Bangladesh's economy. Production and marketing together contribute about 50 percent share of the GDP. Climate variability has large impacts both positive and negative on agriculture. Table 1 shows the descriptive statistics of dependent and independent variables where surplus-deficit is considered as a dependent variables. Table 1-4 shows the summary statistics and other related statistical test results where R^2 = .991, implying that 99.1% of the variability in surplus-deficit was explained by the variables included in the model.

Table 1: Descriptive Statistics of Food grain Surplus-Deficit Production Variables

Variables		Mean	Std. Deviation	N
Dependent	SUR_DEF	22.4345	283.1435	64
Independent	AUS	27.5511	24.5006	64
	AMAN	161.7462	170.8619	64
	BORO	172.2802	233.3662	64
	ALL_RICE	361.5772	324.8175	64
	WHEAT	27.6409	35.0202	64
	ALL_FG	389.2164	331.7404	64
	NFG_PROD	350.2933	298.5661	64
	Mid-yrpop	1999.22	1312.13	64
	FG_REQ	331.2716	217.4202	64

Note: SUR_DEF = surplus-deficit, AUS = Aus rice, AMAN =Aman rice, BORO=Boro rice,

ALL_RICE = All rice grain, WHEAT = Wheat, ALL_FG = All Food Grain, NFG_PROD =Net Food Grain Production, Mid-yrpop = Mid-year Population, FG_REQ = Food Grain Requirement.

Overall (F-test) regression coefficients were statistically significant and some regression coefficients were statistically significant by using single t-test. Also Durbin-Watson statistic showed that the calculated d value d=2.054 (where tabulated d value d_L=1.20, d_u=1.41) the null hypothesis was not rejected at the 5% level of significance. Thus there was no positive autocorrelation at all.

Table 2: Summary for the Food grain Surplus Deficit Regression Model

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df 1	df 2	Sig. F Change	
1	.995	.991	.990	28.1683	.991	1261.503	5	58	.000	2.054

a Predictors: (Constant), FG_REQ, WHEAT, AUS, BORO, AMAN

b Dependent Variable: SUR_DEF

Histogram

Dependent Variable: SUR_DEF

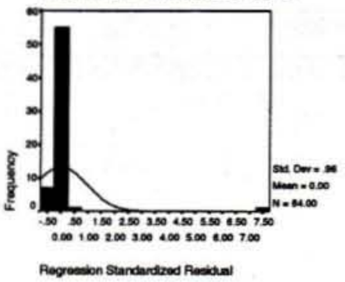

Figure 1: Visual identification of the shape of the Normal Distribution.

Normal P-P Plot of Regression Stand

Dependent Variable: SUR_DEF

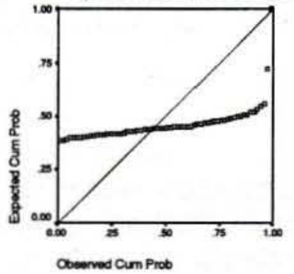

Figure 2: Normal Probability Plot of the Standardized Regression Residual.

Fig.1 & 2 show that histogram and normal probability plot do not indicate any serious departure from the assumptions. Similar result is found by Draper and Smith (1981). These statistical tests on residuals would make relatively confident that including them would not seriously limit the use of the model.

The fitted regression model (Table 4) shows that Aus, Aman, Boro and Wheat have positive impact on surplus-deficit whereas foodgrain requirement has negative impact on surplus-deficit. Also R^2=.991 and F= 1261.503 values are significantly improved through variable selection and model adequacy test. Overall (F-test) regression coefficients are statistically highly significant. Among the individual coefficients, all coefficients are statistically highly significant (Table 1-4).

Table 3: Analysis of Variance Table (ANOVA) of Multiple Regression Model

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5004703.487	5	1000940.697	1261.503	.000
	Residual	46020.155	58	793.451		
	Total	5050723.642	63			

a Predictors: (Constant), FG_REQ, WHEAT, AUS, BORO, AMAN

b Dependent Variable: SUR_DEF.

Table 4: Summary Statistics for the Fitted Foodgrain Surplus Deficit Regression Model.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
Constant	7.626	7.543		1.011	.316	-7.47	22.72					
AUS	.953	.153	.082	6.227	.000	.647	1.259	.04	.63	.078	.896	1.116
AMAN	.882	.023	.532	39.11	.000	.837	.928	.47	.98	.490	.848	1.179
BORO	.898	.016	.740	54.58	.000	.865	.931	.62	.99	.684	.854	1.171
WHEAT	.871	.103	.108	8.469	.000	.665	1.077	.21	.74	.106	.971	1.030
FG_REQ	1.005	.018	-.772	54.44	.000	1.04	.968	-.31	.99	.682	.782	1.279

a Dependent Variable: SUR_DEF

5. Conclusions

Climate variability is a strong feature of the country. It has large impacts both positive and negative on agriculture. The impact is associated with gains and losses of annual production and profits. Agriculture production in Bangladesh could be affected by the social impact while the rapid increase in human population might cause a shortage of food. The fitted regression model showed that Aus, Aman, Boro and Wheat production had positive impact on surplus-deficit whereas food grain requirement had negative impact on surplus-deficit. This study is important in estimating the effects of global warming on food grain distribution system in Bangladesh. This study will help identify the policies needed for the development of competitive and efficient agricultural markets that can contribute towards reducing rural poverty and promoting agricultural economic growth in the country.

References

Ahmed, R. and F. Goletti, 1997, Food policy and market reform in Viet Nam and Bangladesh. IFPRI Annual Report, Washington, D.C., U.S.A., 1997

Al-Farouq, A. and S. Huq, Adaptation to climate change in the coastal resources sector of Bangladesh: some issues and problems. In J. B. Smith et al. (eds.) Adaptation to Climate Change: An International Perspective. New York;Springer-Verlag, 1996, PP. 335-342.

Ali A. Vulnerability of Bangladesh to climate changes and sea-level rise through tropical cyclones and storm surges. Water, Air, and Soil Pollution Vo. 91, No. 1-2, 1996, PP. 171-179.

Ali, A., Climate change impacts and adaptation assessment in Bangladesh, Vol. 12, 1999, PP. 109-116.

Allen, D.M., The relationship between variable selection and data augmentation and a method for prediction. Technometrics, Vol. 16, 1974, PP. 125-127

BBS, Year Book of Agricultural Statistics of Bangladesh, Govt. of Bangladesh., 1998.

Box, G.E.P. and G.M.Jenkins, Time Series Analysis, Forecasting and Control. San Francisco, 1976

Chowdhury, N., Rice market in Bangladesh: A case study in structure, conduct and performance. IFPRI, Bangladesh Food Policy Project, No. 22., 1992.

Davies, P., A. H. M. R. Imon and M. M. Ali, A conditional expectation method for improved residual estimation and outlier identification in linear regression. International Journal of Statistical Sciences, Special Issue, Vol. 3, 2004, PP. 191-208.

Draper, N.R. and H.Smith, Applied Regression Analysis, Wiley, New York., 1981

Durbin, J. and G.S.Watson, 1971, Testing for serial correlation in least squares regression III. Biometrika, Vol. 58, 1971, PP. 1-19

Hampel, F. R., E. M. Ronchetti, P.J. Rousseeuw and W. A. Stahel, Robust Statistics: The Approach Based on Influence Functions, Wiley, New York., 1986

Hocking, R.R., The analysis and selection of variables in linear regression. Biometrics, Vol. 32, 1976, PP. 1-49.

Karim, Z., S. G. Hussain and M. Ahemd, Assessing impacts of climate variations on food grain production in Bangladesh. Water, Air, and Soil Pollution Vol. 92, No. 1-2, 1996, PP. 53-62.

Mirza, M.M.Q., Global warming and changes in the probability of occurrence of floods in Bangladesh and implications. Global Environmental Changes. *127-138.Vol. 15,No. 2, 2002, PP. 53-62.* E. A. Peck. Introduction to Linear Regression Analysis. John Wiley & Sons, New York, 1982

Mujiruddin, K., Markets and Marketing Policies in Accelerating Agricultural Growth in Bangladesh. Agricultural Sector Review, Compendium Volume IV, Markets and Prices, Dhaka, 1989.

Ohsawa, M., T. Eguchi, N. Tanaka, H. Ikeda, M. Nemoto and Y. Hada, Impacts of Natural Ecosystems. S. Nishika and H. Harasawa (Eds.), Global Warming: The Potential Impact on Japan, Springer-Verlag Tokyo, *1998,pp. 35-99.*

Pal, B.K. and H. Rashid, Food damage to rice crop in Bangladesh. In the Geographical Review, *Vol. 83, No. 2, 1993, PP. 151-159*

Rahman, M.S., M.M.Huq, A. Sumi, M.G.Mostafa and M.R. Azad, Statistical analysis of crop-weather regression model for forecasting production impact of Aus rice in Bangladesh. International Journal of Statistical Sciences, *Vol. 4., 2005, PP. 57-77.*

Rahman. M. S., M. R. Azad and N. Farid, Statistical Analysis of Structure of Prices and Its Implication for Food Policy of Bangladesh. International Journal of Statistical Sciences, *Vol. 3, 2004, PP. 67-74*

Rosenzweig, C. and A. Iglesias, Implications of climate change for international agriculture: crop modeling study, EPA 230-B-94-003, U.S. Environmental Protection Agency, Washington, D.C., 1994

Task Force Report, Reports of the Task Forces on Bangladesh Development Strategies for the 1990s, University Press Limited, 1991.