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Factors Affecting Farmers' Decisions on Fertilizer Use: A Case Study of Rajshahi District in Bangladesh

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Abstract *This study presents empirical evidence to show how socio-economic factors influence the extent and intensity of fertilizer adoption on rice production in Rajshahi district. A multi-stage random sampling technique was used to select 90 rice farmers from the study area. Probit and Tobit regression models were used for analysis. The results of the analysis found irrigation facility to be positively and significantly related to the extent and intensity of fertilizer adoption, while access to credit and non-farm income had an indirect relationship with adoption decision of fertilizer in Probit model. Type of land, irrigation facility and access to credit had a positive and significant influence on fertilizer use but extension service is significantly and negatively related with fertilizer adoption in Tobit model. There were no significant relationships between adoption and education, distance from market and farm income. The results have important implications for the formulation of policies and programs targeted to promotion of fertilizer use in small-scale rice production. These include improved irrigation facility, ease access to credit and extension services and developed rural infrastructures, mainly the rural road network.*

1. Introduction

Bangladesh is predominantly an agricultural country where agriculture contributes 19.42% of GDP and 45% of the labour force is dependent directly or indirectly on agriculture. At present agriculture is growing at 2.46% per annum and at the same time population is growing at 1.37% and is expected to double by

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2025 (BBS, 2013). That means every year more than 2 million new people are added to our existing population, which indicates the need to increase the productivity of agriculture to keep pace with population growth to ensure adequate supply of food in the future. Broad agriculture and rural development sectors have been given the highest priority in order to make Bangladesh self-sufficient in food. Besides, agriculture is directly related to the issues like poverty alleviation, rise in the standard of living, and increased generation of employment. All-out efforts of the government have been there to develop the agriculture sector keeping in view the goals set in the 6th Five Year Plan, National Agriculture Policy (NAP) and Millennium Development Goals.

Bangladesh is gifted with a climate favorable for the cultivation of a wide variety of both tropical and temperate crops. Rice is the staple food for above 152.5 million population in Bangladesh and will continue to remain so in future. Boro rice is one of the major cereal food crops in Bangladesh, which contributed 56.84% to the total rice production during 2008-09, whereas Aus and Aman contributed 43.16% altogether. According to Bangladesh Bureau of Statistics (2013), the total rice production was 33.80 million metric tons in FY 2011-12, among these the production of Aus and Aman was 15.1 million metric tons and Boro was 18.7 million metric tons.

Rice production system depends on various management practices such as irrigation and fertilizer applications, crop management practices, use of new high yielding varieties and modern technologies. Fertilizer is the most important nutrient elements in soils and plays the most vital role in crop production in Bangladesh. Fertilizer application mainly depends on the soil types, growing season, irrigation applications and the cultivars used and agro-climatic conditions of the locations. Urea (Nitrogen), Triple Super Phosphate (TSP), Murate of Potash (MOP), Gypsum and Dasta (ZnSO4) are the major fertilizers applied in agricultural land in various proportions for rice production in Bangladesh (Basak, 2010).

The expansion of modern agricultural farming practices like use of High Yield Variety (HYV) together with intensified cultivation results in an increasing demand for fertilizers. The use of chemical fertilizer is on the increase with the increasing demand for food production in the country. The use of Urea fertilizer alone was the highest and very much essential for rice production. In FY 2010-11, the quantity of Urea fertilizer used was 2.66 million metric tons and the total quantity of fertilizers used was 4.12 million metric tons. In FY 2011-12, the total quantity of fertilizer used was 4.05 million metric tons (BBS, 2012). Every year huge amounts of chemical fertilizer are imported from foreign countries and the import rate is significantly higher for non Urea fertilizer. Domestic production of

Urea fertilizer covered 50% to the total demand, where as TSP (Triple Supper Phosphate) was only 10%, Gypsum was 40% and MOP (Murate of Potash) was fully imported in 2008-09 (Basak, 2010).

Due to rapid population growth and urbanization, Bangladesh has lost 0.08 million hectares of cultivable land every year and there is no way to increase food crop production by expansion of land use in agriculture. This makes the need for intensification of land use through adoption of productivity enhancing technologies such as fertilizer which is crucial for achieving food security. The use of modern agricultural inputs such as chemical fertilizers is generally low compared to the recommended amount in Bangladesh. Farmers of Bangladesh use less amount of Urea fertilizer compared to the nutrient requirement and soil fertility doses. The continuous use of the chemical fertilizers under intensive cropping systems has been considered to be the main cause for declining crop yield and environmental degradation (Basak, 2010). The development of sustainable plant nutrition and pest management strategies requires information on current use of fertilizers by farmers and factors affecting adoption of those inputs (Nkamleu and Adesina, 2000).

The objective of this paper is to determine the socio-economic factors affecting the adoption of chemical fertilizers in Rajshahi District.

2. Review of Literature

Conventional Study on how farmers adopt new technologies gives explanations of the adoption decision and its regulation of occurrence (i.e. whether near the beginning or behind schedule) essentially in relation to the decision maker's perceptual experience and innate characteristics, with 'straggler' at one end and 'innovator' at the other (Rogers, 1995). But, usually, a farmer's decision making process in regard to the adoption of new technologies is complicated. This is because farmers have several objectives (such as social security, food security, sufficient income, a secure asset and so on). And circumspectly the farmers choose 'livelihood strategies' that would help them in their pursuit of these multiple objectives with their limited available resources (Ellis, 1997; Scherr, 1995).

The conventional study of farmers' adoption also streamlines the analytical thinking of the adoption decision by its underlying assumption of the decision-process of a person. The capacity of a farm household to take decisions in relation to technology and resource use differs with respect to age, education, sex, *inter alia,* and concrete decisions can be made subject to an agreement among members of the farm household (Hassan & Fufa, 2006; Gardebroek, 2002; Jackson, 1995; Ellis, 1993). The findings of the study 'Farmers' perceptions and adoption of new agricultural technology: evidence from analysis in Burkina Faso and Guinea, West Africa' carried by Adesina and Forson (1995), provide a strong case for future adoption studies to expand the range of variables used away from the broad socio-economic, demographic and institutional factors to include farmers' subjective perceptions of the characteristics of new agricultural technologies and the variables are ease of cooking rice varieties, varieties that have the capacity to produce tillers fast, ease of threshing and better yield performance.

Adesina and Chianu (2002) ran a study on Nigeria and found that eleven variables were significant in explaining farmers' adoption decisions. The model results show that farmer characteristics that influenced adoption included the gender of the farmers, contact with extension agents, years of experience with agroforestry and tenancy status in the village. Economic factors, proxied by village-level characteristics that condition resource use incentives, were also significant. These variables include the extent of village land pressure, extent of erosion intensity, village fuel wood pressure, importance of livestock as an economic activity in the village and the distance of the village locations from the urban centers.

3. Analytical Framework and Empirical Models of Technology Adoption

The analytical techniques employed in the analysis, were Probit and Tobit regression models. In the case of categorical dependent variables (binomial or multinomial), qualitative choice models of adoption such as the logit and Probit are usually specified. These models are commonly used to analyze situations where the choice problem is whether or not (0-1value range) to adopt a new technology. The Probit specification has advantages over logit models in small samples. The present study therefore employed a Probit to examine determinants of farmers' decision to adopt or not adopt fertilizers on rice. The Probit model specification used in this study is given by

Adoption of Fertilizer (AF) = $F(\propto +\beta x_i) = F(z_i)$ (1)

Where, AF (Adoption of Fertilizer) is the discrete adoption choice variable, *F* is the cumulative probability distribution function, *ß* is the vector of parameters, *x* is the vector of explanatory variables and *z* is the *Z*-score of *ßx* area under the normal curve.

The expected value of the discrete dependent variable in the Probit model conditional on the explanatory variables is given by

$$E[y/x] = 0[1 - F(\beta' x)] + [F(\beta' x)] = F(\beta') \quad (2)$$

While the Probit model is adequate for analyzing the decision that occur over a discrete range such as yes or no, it does not handle the case of adoption choices that have a continuous value range that is truncated from below. This is the typical case for fertilizer adoption decisions where some farmers apply positive levels of fertilizer application while others have zero applications (non-adopters). Intensity of use is a very important aspect of technology adoption because it is not only the choice to use but also how much to apply that is often more important. The Tobit model of Tobin (1958) is used to handle truncated distribution dependent choice variables such as the level of fertilizer use. This study used the Tobit model specification to analyses determinants of the variation in intensity of fertilizer use by rice farmers as given by

$$AD = x\beta(z) + \sigma f(z) + \varepsilon$$

$$AD^*, \; if \;\; AD^* > AD_0 \quad (3)$$

$$O, \; if \;\; AD^* < AD_0$$

Where *AD* is the standard intensity (level of application), AD_0 is the critical value adoption intensity, *x, ß* and *F(z)* are as defined in (1). ß is the standard error, *f(x)* the value of the derivative of the normal curve at a given point (density function).

Adoption of agricultural technologies is influenced by a number of interrelated components within the decision environment in which farmers operate. For instance, Feder *et al* (1985) indentified lack of credit, limited access to information, aversion to risk, inadequate farm size, insufficient human capital, tenure arrangements, absence of adequate farm equipment, chaotic supply of complementary inputs and inappropriate transportation infrastructure as key constraints to rapid adoption of innovations in less developed countries. However, not all factors are equally important in different areas and for farmers with different socio-economic situations.

Socio-economic conditions of farmers are the most cited factors influencing technology adoption. The variables most commonly included in this category are age, education, household size, landholding size, livestock ownership and other factors that indicate the wealth status of farmers. Farmers with bigger land holding size are assumed to have the ability to purchase improved technologies and the capacity to bear risk if technology fails (Feder e*t al.*, 1985). This was confirmed in the case of fertilizer by Nkonya *et al.* (1997) in Tanzania, Hassan *et al.* (1998a) in Kenya and Yohannes *et al. (1990)* in Ethiopia whereas; farm size did not matter in Nepal (Shakya and Flinn, 1985).

The role of education in technology adoption has been extensively discussed in the literature. Education enhances awareness of more sources of information, and is more efficient in evaluating and interpreting information about innovations than those with less education (Wozniak 1984). Education was found to positively affect adoption of improved maize varieties in West shoa, Ethiopia (Alene *et al.,* 2000), Tanzania (Nkonya *et al.,* 1997) and Nepal (Shakya and Flinn, 1985).

Some new technologies are relatively labour saving and others are labour using. For those labour-using technologies like improved varieties of seeds and fertilizer, labour availability plays significant role in adoption. Green and Ngongola (1993) found regular labour to be an important factor that positively influences adoption of fertilizers in Malawi.

On the other hand, age of the household head is an important factor affecting adoption of agricultural technologies. The conventional approach to adoption study considers age to be negatively related to adoption based on the assumption that with age farmers become more conservative and less acceptable of new ideas. On the other hand, it is also argued that with age farmers gain more experience and acquaintance with new technologies more efficiently. Some studies found age to be an important determinant of adoption (Hassan *et al,* 1998b), while others didn't (Voh, 1982, Nkonya *et al.,* 1997*;* Chilot *et al.,* 1998).

The effect of family size on adoption can be ambiguous. It can hinder the adoption of technologies in areas where farmers are very poor and the financial resources are used for other family commitments with little left for purchase of farm inputs (Voh, 1982; Shakya and Flinn, 1985). On the other hand, it can be an incentive for adoption of new technologies as more agricultural output is required to meet the family food consumption needs (Yonannes *et al.*, 1989) or as more family labour is required for adoption of labour intensive technologies (Hassan *et al.*, 1998a).

In addition, adoption of new agricultural technologies depends on a number of institutional factors. The introduction of new technologies creates demand for information useful in making decisions (Wozniak, 1984). Agricultural extension organizations supply useful information about new agricultural technologies. Access to such sources of information can be crucial in adoption of improved varieties (Nkonya *et al.,* 1997; Hassan *et al.*, 1998b; Chilot *et al.,* 1998). Furthermore, risk associate with the adoption of agricultural technologies is another important factor in adoptions (Parikh and Bernard, 1988; Yohannes *et al.*, 1990; Shiyani *et al.*, 2002; Hassan *et al.*, 1998).

The studies reviewed above show inconsistent results about the determinants of adoption of new technologies by farmers. In addition, none of the above studies address how adoption of fertilizer is affected by farmers' perception about the expected rainfall conditions, the perception of farmers about the current prices of fertilizers, technologies and the topographic conditions of rice farm plots.

4. The Specification of Empirical Model

In light of the results of previous empirical research, this study considered a number of explanatory variables in modeling the fertilizer adoption behavior of rice farmers in Bangladesh. Socio-economic factors such as age of the household head, family size, literacy, farm size, extension service, access to credit, distance of market, farm income and non-farm income of the farmers were considered important determinants of adoption. The age of the household head (Age) is measured by years, farm size (farm size) is measured in hectare and literacy (Education) takes a value of 0 if the farmer is illiterate and 1-17 on the basis of school going years. Household size (Household size) is measured by the number of people living in the household. Income from farm sources (Farm Income) and off farm sources (Non-farm Income) are included to reflect the financial ability of the farmer to buy external inputs, both were measured by the amount of income earned from the respective activities. The topographical nature of land (Land Type), which takes the value of one if the plot is low and zero otherwise is included. Furthermore, to see the effect of credit associated with the use of fertilizer, farmers' perception about the credit facility (Access to Credit) during the production year was included. This is measured as one if the farmer receives credit and zero otherwise. Distance of the home of the farmer (Distance from the Market) from the nearby market where fertilizer is available is measured in kilometer is selected to capture the impact of institutional constraints on fertilizer adoption in the area. Agriculture Extension Service program for the farmers is included in the model since it has an important impact on fertilizer application. This is measured by value one if farmers get the service and zero otherwise.

The above explanatory variables were used to estimate the Probit and Tobit models of fertilizer adoption as specified below.

$$\begin{aligned} AF = \beta_0 \; + \; & \beta_1 Age + \beta_2 Land\ type + \beta_3 Literacy + \beta_4 irrigation\ facility \\ & + \beta_5 Farmincome + \beta_6 Nonfarmincome + \beta_7 Household\ size \\ & + \beta_8 Distance\ of\ Market \; + \beta_9 Extention\ service + \beta_{10} Type\ of Seed \\ & + \beta_{11}\ Credit \end{aligned} \qquad (4)$$

Where AF (Adoption of Fertilizer) takes the value of one if farmers use fertilizer more than the minimum required level (minimum required level 351.97 kg per hectare, BRRI, 2010) and zero for using fertilizer below the minimum level in the case of the Probit model and is the level of fertilizer used in kg per hectare of land in the Tobit model.

5. Study Area and Sampling Procedure

The study is conducted in Rajshahi District, located in the Northwest part of Bangladesh. Being part of Barind highlands, the area receives an average annual rainfall of more than 813 mm. Rice, wheat, pulses and maize are the cereals grown in the area. Rice is the staple crop in this district. Being one of the major rice producing districts in the Northwest region, the area has been included in the Barind Multipurpose Development Project since 1985. Firstly, for collecting primary data, a multistage random sampling technique is used for the study. One thana named Poba is randomly selected from nine thanas in Rajshahi district in the first stage. In the second stage, three villages are randomly selected from Poba thana. Source from the district level office of agriculture shows that about 100% of the farmers in the study area use fertilizer in rice production. After listing farmers in each village, 30 respondents are randomly selected using simple random sampling from each village. One purposive sample of a total of 90 farm households is surveyed. The primary data are collected with the aid of a well structured questionnaire, including such variables as quantity of fertilizers applied, age of farmers, year of schooling of farmers, farm size, land type, irrigation facility access to credit, farm income and non-farm income etc.

6. Results and Discussion

The explanatory variables of the Probit model reported in Table 1 had the expected sign. Age is positively but insignificantly related to the adoption of fertilizer suggesting that age of the farmer doesn't bear any significant meaning.

Farmers' expectation of a good rainfall season and ease of access to irrigation facility are positively and significantly associated with fertilizer adoption. Farmers' perception about credit facility is negatively and significantly connected with fertilizer use of the farmers in the study area. High interest rate and difficult official procedure discourage farmers to take credit from banking and non-banking sources for the purpose of fertilizer use. Non-farm incomes of the farmers negatively but significantly affect the farmers' decision of fertilizer adoption.

The factors influencing fertilizer use intensity among the farmers in the study area are shown in Table 2. Irrigation facility and access to credit are significant factors at 5% level of probability in the use of fertilizer in the study area. These imply that farmers with ease of access to irrigation and credit facilities use more fertilizer than those with limited access to irrigation and credit facility.

Table 1 : Estimated Results of Probit Model of Adoption of Fertilizer

Variable	Coefficient	Standard error	z	P-value
Age	0.020875	0.0141509	1.48	0.140
Education	-0.016944	0.0378936	-0.45	0.655
Land Type	-0.236486	0.5090107	-0.46	0.642
Distance from Market	-0.160171	0.1854242	-0.86	0.388
Irrigation Facility	1.543736**	0.6396538	2.41	0.016
Access to Credit	-0.628958*	0.3409387	-1.84	0.065
Extension Service	0.408659	0.3741495	1.09	0.275
Farm Income	1.983060	2.5701206	0.77	0.441
Non Farm Income	-3.812060*	2.3110016	-1.65	0.099
Constant	-1.229850	1.0750412	-1.14	0.253

Authors Own Calculation; Restricted Log likelihood -39.314; Chi-Square 0.0364; *** Significant at 1% ; ** Significant at 5% and * Significant at 10%

Type of land is significant and has a positive sign. This indicates that the adoption and intensity of the use of fertilizer in low land is higher than upland. The extension service in the study area has a significant but negative relationship to the decision of the use of chemical fertilizer. It is significant at 10% level and implies that by increasing the frequency of extension service in one unit reduces the excess fertilizer use by 71.36 kg per hectare.

Table 2 : The Tobit Model of Fertilizer Adoption in Rajshahi District

Variable	Coefficient	Standard error	z	P-value
Age	0.0328621	0.9717153	0.03	0.973
Education	1.117135	2.609355	0.43	0.669
Land Type	56.12218*	34.00643	1.65	0.099
Distance from Market	4.764358	12.74537	0.37	0.709
Irrigation Facility	78.91047**	38.15438	2.07	0.039
Access to Credit	90.38503**	39.22689	2.30	0.021
Extension Service	-71.35883*	40.29018	-1.77	0.077
Farm Income	-0.0002317	0.0001663	-1.39	0.163
Non Farm Income	-0.0000565	0.0001293	-0.44	0.662
Constant	307.6936	68.49777	4.49	0.000

Authors Own Calculation; Restricted Log likelihood -420.77823; Chi-Square 12.69; *** Significant at 1% ** Significant at 5% and * Significant at 10%

7. Conclusions and Policy Implications

Chemical Fertilizer is considered the most important input for the achievement of increased agricultural productivity and food security status of farm households in Bangladesh. However, fertilizer adoption remains very low, especially among small-scale and marginal farmers in the country. The results of this study show that the irrigation facility, access to credit, land type, non-farm income significantly affect the use and intensity of adoption of fertilizer in the study area.

In situations where the expected rainfall condition is bad or irrigation facility is limited, farmers are unwilling to use fertilizer. This is because farmers are not insured against losses as a result of draught weather or shortage of irrigation facility and forced to pay the cost of fertilizer they received on credit. Agricultural research has to focus on the development of moisture stress tolerant and early maturing varieties. In addition, the expansion of small-scale irrigation projects like Barind Multipurpose Development Project in rural areas can help overcome the adverse effects of rainfall shortage or limited facilities of irrigation experienced by most parts of the country.

The government and its agricultural extension office should impart knowledge and skills in farmers through avenues such as training, extension agent contact with farmers or any other means of capacity building. Collateral free loan facility with low interest rate and exemption from liabilities of loan in bad harvesting season will encourage farmers to use more fertilizers. Government should also establish institutions and encourage formation of cooperatives that offer micro-finance and loans to farmers in order to mobilize savings and maximize the availability of credit to the farmers. The development of rural roads reduces the transaction cost associated with acquisition of farm inputs and sale of farm products. This enables farmers to buy farm inputs at lower prices and sell their produce at competitive prices. More effort in expanding roads in rural areas is therefore needed.

References

1. Basak, J.K. (2010). Fertilizer Requirement for Boro Rice Production in Bangladesh. Unnayan Onneshan – The Innovators.
2. Ellis, F. (1997). Hoesehold Strategies and Rural Livelihood Diversification. Paper presented at Annual Conference of Development Studies Association, University of East Anglia,England, 11-13 September 1997.
3. Hassan, R.M. and Fufa, B. (2006). Determinants of Fertilizer Use on Maize in Eastern Ethiopia: A Weighted Endogenous Sampling Analysis of the Extent and Intensity of Adoption. Agrekon, Vol 45, No 1, 38-49, March 2006.
4. BRRI (2010). Bangladesh Rice Research Institute, Ministry of Agriculture, Government of the People's Republic of Bangladesh.
5. Nkamleu, G. B. and Adesina, A. A. (1999). Determinants of Chemical Inputs use in Peri-urban Lowland Systems: Bivariate Probit Analysis in Cameroon. Agricultural Systems 63 (2000) 111-121.
6. Rogers, E. M. (1995). The diffusion of Innovations (4^{th} ed.). New York, Free Press.
7. Scherr, S. J. (1995). Economic Factors in Farmer Adoption of Agroforestry: Patterns Observed in western Kenya. World Development, 23, 787-804. Http://dx.doi.org/10.1016/0305-750X (95)00005-W
8. Tobin. J. (1958). Estimation of Relationships for Limited Dependent Variables. The Econometrica 26:24-36.