Microdeterminants of Poverty among the Farming Population in Bangladesh

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Abstract: *This paper examines the determinants of poverty among the farming population of Bangladesh by applying a probit model with heteroscedastic structure (hetprobit). The model diagnostic reveals that the choice of hetprobit instead of a standard probit is more appropriate in this case. Among the socioeconomic factors, land ownership, farm resource endowments and non-agricultural income significantly reduce the probability of becoming poor. On the other hand, the number of dependants and education of female members significantly increase the likelihood of becoming poor. Adoption of green revolution technology does not seem to have any significant influence on the likelihood of being poor. However, regional and village level factors have significant influence on poverty. The likelihood of poverty is significantly lower in regions with developed infrastructure and high soil fertility. Poverty is also significantly lower in Comilla and Jamalpur, implying that geographical location matters. Policies to promote land ownership and farm resource endowments, investment in rural infrastructure development and soil fertility improvement will significantly reduce poverty among the farming population of Bangladesh.*

Keywords: *poverty; probit model with heteroscedastic structure; Bangladesh*

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Bangladesh, a predominantly agrarian economy and a country suffering from widespread malnutrition and hunger, has relied on extensive diffusion of 'green revolution' technology to feed its rapidly growing population. Consequently, over the past four decades, the major thrust of national policies was directed towards diffusion of green revolution technology aimed at meeting a tripartite objective of increasing food production, generating employment and increasing the incomes of rural households, thereby complementing the national goal of 'poverty alleviation'. Various impact studies[1] of the green revolution in Bangladesh, starting from the early 1970s until today, consistently revealed that these tripartite objectives were largely being met, implying that poverty must have been reduced or at least contained in rural areas.[2]

On the other hand, there is a growing debate in the poverty literature on whether poverty has declined or increased in Bangladesh.[3] Wodon (1997) and Ravallion and Sen (1996), working on data from a regional panel of four household expenditure surveys (HESs) for the period 1983–1992, indicated that poverty had increased since 1985/86 in both rural and urban sectors, largely due to higher poverty in rural areas. Ravallion and Sen (1996) estimated an implied rate of 1.5–2.0% increases in total numbers of poor during the period under consideration. In contrast, Wodon (2000), with the addition of 1996 HES data on the existing panel, claimed a significant decline in poverty in recent years, with increasing inequality, especially in urban areas.

Knowledge on the determinants of poverty is limited and has remained a major concern for policy makers for decades, as these are expected to differ widely across regions. Answers to the question of whether or to what extent household characteristics (for example, education, land ownership, demographics and sources of income) and/or regional characteristics (for example, the state of infrastructure development, soil fertility status and location) influence poverty in rural areas can provide significant insights into the issue. Also, explicit knowledge on the magnitude and direction of the contribution of modern agricultural technology and/or the green revolution to rural poverty will have important policy implications, particularly for nations in which technological progress in agriculture is deemed a prerequisite for economic growth and development.

The present paper attempts to seek answers to the aforementioned questions for Bangladesh, one of the most vulnerable countries in terms of food security, hunger and poverty. The analysis is based on an in-depth farm-level sample survey from 21 villages in three agroecological regions for the year 1996. The paper proceeds as follows. The next section provides information on data and construction of region-specific poverty line expenditure of sampled households. The subsequent two sections provide the analytical framework of the study and discuss the results. The final section concludes and draws policy implications.

Data and poverty line expenditure

Primary data for the study came from an intensive farm survey conducted from February to April 1997 in three agroecological regions of Bangladesh, including soil[4] samples from representative locations and information on infrastructural[5] facilities. Samples were collected from eight villages in Jamalpur Central subdistrict of Jamalpur representing wet agroecology, six villages in Manirampur subdistrict of Jessore representing dry agroecology, and seven villages in Matlab subdistrict of Comilla, representing wet agroecology in an agriculturally developed area. A total of 406 farm households (175 in Jamalpur, 105 in Jessore and 126 in Comilla) were selected from these 21 villages for data collection following a multistage stratified random sampling procedure. Details of crop input–output data were collected for the crop year 1996.[6]

The cost of basic needs (CBN) approach, which is considered superior to other methods, is used to construct the region-specific poverty line expenditure (Wodon, 2000, 1997; Ravallion and Sen, 1996). In constructing the food poverty expenditure as a first step, a cost-minimizing long-term diet set with available food items that attain the recommended nutrition level of 2,112 kcal and 58 grams of protein per capita per day proposed by Mian (1978) is utilized. In addition, expenditure on non-durable goods and/or non-food allowance is estimated at 30% of the food poverty line.[7] The region-specific poverty line expenditures, thus constructed, reveal large differences across regions, with an overall estimate of Tk5,409 per capita per year (Table 1; currently (mid-2009) Tk100 = US$1.45). The last line of Table 1 provides a roughly comparable estimate of poverty line expenditure for the year 1995/96 based on the HES by Wodon (1999). It seems that the current estimate is about 7–13% lower than Wodon's estimate, largely because a group of areas is represented in his estimate and the prices are taken from retail markets that are generally higher than those in the village markets.

Household or family income is defined as the return to family labour and the assets owned after the current cost of production (excluding family labour and rent for land and assets) is deducted from the gross value of production (Ahmed and Hossain, 1990). Current cost is the cost incurred by individual households in purchasing inputs, hiring labour, hiring animal power services and renting services. Income from agriculture comprises income from various crops, fisheries, livestock and lease income from land. Crop income is derived from the aggregate of local and modern varieties of rice (all season), wheat, jute, potato, pulses, spices, oilseeds, vegetables and cotton (for details of components of income and their derivation, see Rahman, 1999).

Analytical framework: the heteroscedastic probit model

In designating the households as poor, a simple head-count ratio (that is, population below the poverty line expenditure: C_k) is used. The impact of the variables, including household demographics, sources of income and regional characteristics, on the probability of being poor can be estimated with probit (logit) regressions. In probit estimation, the actual per capita income (y_i) is not observed. What we observe is a dummy variable I_i – which takes the value of 1 if $y_i<C_k$ (that is, for a poor household) and 0 if $y_i>C_k$ (for non-poor households). We model the probability that the household is poor as:

$$Pr[I_i = 1] = F(X_i\beta) \text{ and}$$

$$Pr[I_i = 0] = 1 - F(X_i\beta) \quad (1)$$

where F is the cumulative density of the standard normal distribution and X_is are the characteristic variables. The maximum likelihood (ML) estimates of β are known to be consistent, asymptotically efficient and asymptotically normally distributed for a correctly specified model.

Equation (1) implies that:

$$E(I_i) = F(X_i\beta)\,\frac{\partial E(I_i)}{\partial X_j} \quad (2)$$

and thus a change in the probability of being poor with respect to the jth independent variable is given by:

$$\frac{\partial E(I_i)}{\partial X_j} = F(X_i\beta)\beta \quad (3)$$

where $f(.)$ is the normal density function.

However, Parikh and Sen (2006) note that after standard probit model estimation, the null hypothesis of homoscedasticity needs to be tested, because if the null hypothesis is rejected, the estimates obtained are biased and inconsistent in such models. Therefore, we relax the assumption of homoscedasticity by allowing the variance of the error term to vary according to

$$\sigma_i^2 = \{\exp(Z_i\gamma)\}^2 \quad (4)$$

where Z is a vector of variables and γ is a vector of coefficients. The resulting multiplicative heteroscedastic probit model is provided by:

Table 1. Poverty line income required to fulfil nutritional and other requirements, 1996.

Food item	**Quantity (gm) of food included in optimal diet**	**Cost (Tk) of attaining the optimal diet evaluated at region-specific retail market prices**			
		Jamalpur region	*Jessore region*	*Comilla region*	*All regions*
Rice	432.6	4.90	4.36	4.46	4.62
Wheat	58.3	0.64	0.58	0.64	0.62
Potato	36.7	0.15	0.14	0.15	0.14
Lentil	25.0	0.53	0.54	0.53	0.53
Fish	38.3	2.11	2.43	2.24	2.24
Meat	1.7	0.11	0.13	0.11	0.12
Milk	31.1	0.48	0.43	0.53	0.50
Dried milk	2.5	0.55	0.55	0.55	0.55
Sugar	27.2	0.70	0.70	0.70	0.70
Oil	12.2	0.70	0.69	0.63	0.68
Onion	8.5	0.09	0.07	0.07	0.08
Non-leafy vegetables	86.8	0.38	0.58	0.52	0.53
Leafy vegetables	20.0	0.09	0.09	0.10	0.09
Cost of food per capita per day	11.43	11.29	11.23	11.40	
Annual cost of food		4,172.0	4,120.9	4,099.0	4,161.0
Annual cost of non-food items		1,251.6	1,236.3	1,229.7	1,298.3
Poverty line expenditure per year per capita		5,423.6	5,357.2	5,328.7	5,409.3
Roughly comparable estimates of power poverty line expenditure for 1995/96[a]		6,252.0	5,772.0	6,180.0	–

[a] Taken from Wodon (1999).
Source: Adapted from Rahman (1999).

$$\Pr(I_i = 1) = F\{\{X_i\beta/\exp(Z_i\gamma)\} \tag{5}$$

The null hypothesis of $\gamma = 0$ is to be tested to check the assumption of homoscedasticity.

The marginal effects for a probit model with heteroscedastic structure for a variable w_k that could be in X or Z, or both, is given by:

$$\frac{\partial(\Pr I_i = 1)}{\partial w_k} = f\left[\frac{X_i\beta}{\exp(Z_i\gamma)}\right]\frac{\beta_{ik} - (X_i\beta)\gamma_{ik}}{\exp(Z_i\gamma)} \tag{6}$$

Only the first (second) term applies if w_k appears only in $X(Z)$.

Empirical model

The headcount ratio (the proportion of households falling below the estimated poverty line expenditure) is used as the dependent variable. The variable takes the value of 1 if the farm household is poor, and 0 otherwise. The socioeconomic variables determining the probability of becoming poor are: amount of land owned, tenurial status, value of farm capital assets, proportion of area allocated to modern rice technology, number of dependants, farmer education, farming experience, highest level of female education in the household, share of non-agricultural income, index of underdevelopment of infrastructure, and index of soil fertility and dummy variables for the Comilla and Jamalpur regions.

In Bangladesh, land ownership serves as a surrogate for a large number of factors as it is a major source of wealth and influences decisions to choose crops. Also, the impact of tenancy on the extent of poverty is not clearly known. Hence, the amount of land owned (to represent wealth) and the tenurial status (value is 1 if the farmer is purely a tenant, and 0 otherwise) are incorporated to test their independent influence on poverty. The level of farm resource endowments (reflected by the value of farm capital assets, which include the value of livestock resources) may influence poverty as it also reflects the wealth of farm households.

The impact of technological change and/or the green revolution is captured by specifying the proportion of the cultivated area allocated to modern rice. This measure is the most commonly used indicator of green revolution diffusion in Bangladesh (for example, see Hossain, 1989; Hossain *et al*, 1990; Ahmed and Hossain, 1990).

Use of the education level of the farmer as an explanatory variable in poverty analysis is common (for example, Wodon, 2000, 1997; Parikh and Sen, 2006). The education variable is used as a surrogate for a number of factors. At the technical level, access to information as well as capacity to understand the technical aspects and profitability related to farming may influence earnings and hence may affect the probability of being poor. The justification for including farming experience is straightforward. Experienced farmers are more likely to succeed in farming and earn relatively more, which in turn would affect the probability of being poor. Inclusion of female education is not very common in the existing literature, but it may have an influence on poverty.

As with the case of education, inclusion of household size to reflect subsistence pressure is fairly common in poverty studies (for example, Wodon, 2000, 1997; Parikh and Sen, 2006). However, this study provides a more specific measure, that is, the actual number of dependants (defined as family size – number of working members) to examine the influence of subsistence pressure on poverty among these farm households.

The percentage of income earned off-farm is included

Table 2. Summary statistics of the variables.

Variables	Unit of measurement	Mean	Standard deviation	Minimum	Maximum
Number of poor	Proportion	0.59	0.49	0.00	1.00
Socioeconomic factors					
Amount of land owned	Ha	0.65	0.77	0.00	4.26
Tenurial status	Proportion	0.14	0.35	0.00	1.00
Value of farm asset	Thousand taka	55.38	116.85	0.05	1,392.16
Proportion of area under modern rice technology	Proportion	0.55	0.34	0.00	1.00
Number of dependants	Persons	4.00	2.31	0.00	13.00
Farmer education	Completed years of schooling	3.74	4.26	0.00	15.00
Farming experience	Years	25.51	14.21	0.00	70.00
Highest female education	Completed years of schooling	4.28	3.92	0.00	15.00
Share of non-agricultural income	Proportion	0.22	0.31	0.00	0.95
Village/regional level factors					
Index of underdevelopment of infrastructure	Number	33.32	14.95	14.87	73.55
Index of soil fertility	Number	1.68	0.19	1.38	2.00
Comilla	Dummy	0.31	0.46	0.00	1.00
Jamalpur	Dummy	0.43	0.49	0.00	1.00
Number of observations		406			

to reflect the relative importance of non-agricultural work in these farm households. It may also reflect farmers' increased ability to combat poverty, as in general, non-agricultural sources provide higher levels of earnings (Rahman, 1999).

Infrastructure affects agricultural production indirectly through prices, diffusion of technology and use of inputs, and has a profound impact on the incomes of the poor (Ahmed and Hossain, 1990). The state of infrastructure implies improved access to markets and institutions, as well as better access to information and higher returns from farming by lowering transportation costs and enabling timely sales, and hence may influence poverty. This effect is captured by the index of underdevelopment of infrastructure. The index of soil fertility is incorporated to examine its influence on poverty, as fertile regions are expected to provide better crop yields and therefore higher returns.

Regional dummy variables for Comilla (an economically developed region) and Jamalpur (an intensive agricultural region) are included to examine whether poverty has a geographic dimension, as the literature implies that regional factors matter (Ravallion and Wodon, 1999). The influence of the remaining region of Jessore is subsumed in the intercept term.

Results

Summary statistics of the variables used in the heteroscedastic probit model are presented in Table 2. The actual headcount ratio estimated from the sampled households is 0.59, which is strikingly close to the estimate of 0.60 (Hossain *et al*, 1990) based on a nation-wide selected sample survey for the crop year 1987; 0.58 (Wodon, 1997) based on the HES for 1991/92; and 0.57 (Wodon, 1999) based on the HES for 1995/96 respectively. The farm-specific variables provide a summary of the characteristics of these farms. The amount of land owned per farm is 0.65 ha. Only 14% of farmers are purely tenants (no owned cultivable land). The average level of farmer education is less than four years; experience in farming is 26 years; average number of dependants is four persons; 55% of the total cultivated area is allocated to modern rice; 22% of income is derived off-farm; and the highest level of female education in the household is 4.3 years.

Table 3 presents the maximum likelihood estimation of both the standard probit and the heteroscedastic probit (hetprobit) model. Stata-8 is used for the analysis (StataCorp, 2003). We have specified the Huber-White robust variance co-variance estimator for both the models. The test of homoscedasticity of the disturbance term (H_0: $\gamma = 0$) is strongly rejected at the 5% level of significance ($p < 0.05$), implying that the heteroscedastic probit model is the correct choice. Also, notable differences can be observed between the regression coefficients of the two models. More importantly, influences of two variables (tenurial status and farmer education) that are significant in the standard probit model disappear in the hetprobit model. About 82% of the cases are accurately predicted and the McFadden R^2 is estimated at 0.40. A large proportion of the variables included is significantly different from zero at the 5% level at least, implying a good fit.

Land ownership, farm resource endowments (farm capital assets) and share of non-agricultural income significantly reduce the probability of being poor, as expected. Wodon (2000, 1997) also concluded that the lack of land ownership was a major determinant of poverty in rural regions in Bangladesh. Van den Berg and Kumbi (2006) note that general growth of the non-farm economy is likely to benefit the poor in Ethiopia, although there is a debate that growth in non-farm economy increases inequality among households (for example, Rahman, 1999;

Table 3. Determinants of poverty among farmers in Bangladesh.

Variables	Probit model coefficients	t-ratio	Hetprobit model coefficients	t-ratio
Constant	2.441**	2.03	3.834**	2.37
Socioeconomic factors				
Amount of land owned	–0.888***	–2.88	–1.681***	–3.72
Tenurial status	0.502*	1.81	0.380	1.17
Value of farm asset	–0.006***	–3.54	–0.009***	–2.66
Proportion of area under modern rice technology	0.087	0.31	–0.055	–0.16
Number of dependants	0.267***	5.18	0.392***	3.72
Farmer education	–0.058**	–2.31	–0.041	–1.38
Farming experience	–0.002	–0.41	–0.003	–0.38
Highest female education	0.070***	2.56	0.103***	3.09
Share of non-agricultural income	–2.782***	–7.30	–3.497***	–4.72
Village/regional level factors				
Index of underdevelopment of infrastructure	0.028***	2.99	0.044***	2.86
Index of soil fertility	–1.058*	–1.78	–1.899**	–2.25
Comilla	–0.631*	–1.81	–1.059**	–2.23
Jamalpur	–1.717***	–4.58	–2.218***	–3.48
Model diagnostics				
Pseudo log-likelihood	–164.555		–153.173	
McFadden R^2	0.40			
Wald test (χ^2 with 13 df)	82.94***		31.38***	
Het-test (χ^2 with 5 df)			13.92**	
Accuracy of prediction (%)	–		81.53	

*** Significant at 1% level ($p < 0.01$).
** Significant at 5% level ($p < 0.05$).
* Significant at 10% level ($p < 0.10$).

Block and Webb, 2001). However, Nargis and Hossain (2006), using nationally representative panel data collected in 1988, 2000 and 2004 in Bangladesh, concluded that occupational shift towards the non-farm sector (for example, trade, business and services) enhanced significant income growth. A similar conclusion is also provided by Estudillo *et al* (2006) for the Philippines and by Cherdchuchai and Otsuka (2006) for Thailand respectively.

Tenancy seems to increase the probability of being poor only when the model is mis-specified (the standard probit model) and the influence vanishes in the correctly specified model (hetprobit); the case of farmers' education is similar. The poverty-reducing effect of farmers' education vanishes in the hetprobit model. The average of less than four years of farmers' education may not necessarily exert a discernible influence on decision making to lift farm households out of poverty. Deb (1995) noted that education in Bangladesh was not agriculturally oriented and hence did not contribute to agricultural growth, which might in turn affect the capacity of farm households to move out of poverty.

The highest education level of any female member of the household has a counterintuitive influence. The reason for this may be that the best educated female member (who is predominantly the spouse or adult daughter) does not contribute significantly to household decision making and/or may not be present in the household, and therefore does not influence the economic condition of the household. Wodon (2000), however, noted that returns to education on household income were large and similar for both household heads and their spouses. But it seems that the effect is pronounced only when the members have completed secondary school (that is, 10 years of schooling).

Subsistence pressure significantly increases the probability of being poor, which is also corroborated by Wodon (2000, 1997) and Parikh and Sen (2006) for Bangladesh and India respectively.

The influence of location and regional characteristics in reducing poverty is very pronounced, as expected. The probability of being poor is significantly lower in infrastructurally developed regions[8] and areas with fertile soils. The reason for this is that a developed infrastructure provides the opportunity to undertake on-farm as well as off-farm activities, to ease the constraints of input deliveries and output sales as well as to facilitate access to information and extension services more easily. Higher soil fertility opens up opportunities for more gains in the production of existing crops and adoption of modern technology as well as diversified cropping systems that fetch a higher income.

The impact of technological change and/or the green revolution is captured by incorporating the proportion of area allocated to modern rice, which seems to have no influence at all. In other words, adoption of modern rice technology does not necessarily guarantee that farm households will move out of poverty, which is in contrast to the conclusions of Hossain (1989) and Hossain *et al* (1990). One explanation may lie in the differences in the timing of data collection. For example, Hossain (1989) used data collected in 1982, and Hossain *et al* (1990) used

Table 4. Marginal effects of poverty determinants.

Variables	Probit model	t-ratio	Hetprobit model	t-ratio
Socioeconomic factors				
Amount of land owned	–0.331***	–2.80	–0.601***	–6.01
Tenurial status	0.171**	2.08	0.121	1.22
Value of farm asset	–0.002***	–3.44	–0.003***	–2.67
Proportion of area under modern rice technology	0.032	0.31	–0.018	–0.16
Number of dependants	0.100***	5.08	0.130***	5.92
Farmer education	–0.022**	–2.34	–0.011	–1.08
Farming experience	–0.001	–0.41	–0.001	–0.38
Highest female education	0.026***	2.52	0.036***	3.61
Share of non-agricultural income	–1.039***	–7.23	–1.172***	–7.60
Village/regional level factors				
Index of underdevelopment of infrastructure	0.011***	2.99	0.015***	3.60
Index of soil fertility	–0.395*	–1.79	–0.627***	–2.50
Comilla	–0.241*	–1.81	–0.347***	–2.48
Jamalpur	–0.595***	–5.71	–0.652***	–6.09
Predicted probability of being poor	0.642		0.592	

*** Significant at 1% level (p <0.01).
** Significant at 5% level (p <0.05).
* Significant at 10% level (p <0.10).

data collected in 1987. It is generally believed that the green revolution had reached a mature stage from the late 1980s and the productivity from this technology fell thereafter (Coelli *et al*, 2003). Also, due to the rising costs of production, the profitability of growing modern rice over traditional rice varieties had fallen from 123.6% in 1987 (Hossain *et al*, 1990) to 96.9% in 1996. Furthermore, the yield advantage had also fallen from 103.7% to 80.2% during the same period.

Poverty is significantly lower in Comilla (an economically developed region) and Jamalpur (an intensive agricultural area with very high cropping intensity), which implies that geographical location does matter, as indicated by Ravallion and Wodon (1999) and Wodon (2000, 1997).

The marginal effects of the probit estimates are presented in Table 4. The predicted rate of probability of being poor exactly matches the actual headcount ratio of 0.59, which provides confidence in our results. As can be seen from Table 4, the magnitude of effects is larger in the correctly specified model (hetprobit), with lower values of standard errors as compared with the standard probit model. The highest level of poverty-reducing influence is in the non-agricultural income share, followed by land ownership. An increased number of dependent persons in a household sharply increases the probability of being poor.

Conclusion and policy implications

Factors determining poverty in rural households are complex. It is clear from the analysis that selected socio-economic factors as well as regional/locational factors significantly influence the probability of being poor. As a whole, it is encouraging to note from the analysis that factors within the realm of household decision-making processes, such as land ownership, farm resource endowments and non-agricultural income have a synergistic influence in reducing poverty. Also, the inherent advantage represented by a developed infrastructure and improved soil fertility status in reducing poverty is encouraging.

The policy implications are clear. Land reform policies that focus on delegating land ownership to landless and/or marginal farmers will have a significant influence on poverty reduction. Also, policies that enable farmers to accumulate farm resource endowments, particularly through the development of the livestock resources, constitute other avenues through which to reduce poverty. Investment in the development of rural infrastructure as well as soil fertility improvement will significantly reduce the probability of being poor. Another significant factor influencing poverty reduction is the share of non-agricultural income of the household, which in turn improves the development of rural infrastructure. Ahmed and Hossain (1990) conclude that infrastructure raises the income of the poor by 33% (which includes a doubling of wages and an increase in income from business and industries of 17%), thereby reinforcing our argument on improving rural infrastructure. The poverty-reducing effect of non-agricultural income source has also been clearly demonstrated by Nargis and Hossain (2006), Estudillo *et al* (2006) and Cherdchuchai and Otsuka (2006) for Bangladesh, the Philippines and Thailand respectively. Furthermore, the promotion of farmers' education (which demonstrated the expected sign) is worth pursuing as it has a positive effect on earnings (Wodon, 2000, 1997) and hence could reduce poverty in the long run (Estudillo *et al*, 2006). However, the challenge to realize all these policies is formidable, particularly for a resource-scarce economy such as that of Bangladesh.

Notes

[1] Several studies exist on the impact of the 'green revolution' in Bangladesh. However, the notable ones, based on large-scale and/or multiple round sample surveys, are Hossain (1989); Ahmed and Hossain (1990); and Hossain *et al* (1990).

[2] Poverty and inequality were found to be relatively lower in villages with a higher level of modern agricultural technology adoption (Hossain, 1989; Hossain *et al*, 1990; and Hossain and Sen, 1992).

[3] There were widespread claims of a reduction in poverty in the 1980s, which were later challenged by Hossain and Sen (1992), Ravallion and Sen (1996) and Wodon (1997), who identified the methods of poverty measurement applied to household expenditure survey (HES) data as the main cause for controversy.

[4] The soil fertility index is constructed from test results of soil samples collected from the study villages during a field survey for the crop year 1996. Ten soil-fertility parameters were tested. These were: (1) soil pH, (2) available nitrogen, (3) available potassium, (4) available phosphorus, (5) available sulphur, (6) available zinc, (7) soil texture, (8) cation exchange capacity (CEC) of soil, (9) soil organic matter content and (10) electrical conductivity of soil. A high index value refers to better soil fertility (for details on soil testing methods, see Rahman and Parkinson, 2007).

[5] The index of infrastructure is constructed using the cost of access approach. A total of 13 elements are considered for its construction. These are: (1) primary market, (2) secondary market, (3) storage facility, (4) rice mill, (5) paved road, (6) bus stop, (7) bank, (8) union office, (9) agricultural extension office, (10) high school, (11) college, (12) *thana* [subdistrict] headquarters and (13) post office. A high index value refers to highly underdeveloped infrastructure (for details of construction procedure, see Ahmed and Hossain, 1990).

[6] The crop groups are: local Aus rice, modern Aus rice, local Aman rice, modern Aman rice, local Boro rice, modern Boro rice, modern wheat, jute, potato, pulses, spices, oilseeds, vegetables and cotton. Pulses in turn include lentil, gram, chola and khesari. Spices include onion, garlic, chilli, dhania, ginger and turmeric. Oilseeds include sesame, mustard and groundnut. Vegetables include brinjal, cauliflower, cabbage, arum, beans, gourds, radish and leafy vegetables.

[7] Thirty per cent non-food allowance of the food poverty line is standard practice in the context of Bangladesh used by Hossain (1989), Ahmed and Hossain (1990), Hossain *et al* (1990), Hossain and Sen (1992). However, Ravallion and Sen (1996) used 35% as the non-food allowance.

[8] The index is underdevelopment of infrastructure. Therefore, a positive sign indicates a positive influence on the dependent variable. In other words, the probability of being poor is higher in underdeveloped regions, and vice versa.

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