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Research Note

FACTORS AFFECTING ADOPTION OF MODERN VARIETIES OF RICE IN BANGLADESH

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I. INTRODUCTION

Bangladesh is a food deficit country. During the fifties the area, production and yield rate of rice remained at the level as in the earlier decades. Due to planned development it was only from the early sixties that rice output showed considerable growth (Hossain 1984). The supply of food can not be increased only by increasing the area of land since the total cultivable land remained virtually the same since 1980's (Hossain 1989). The main source of increased food supply is the increased land productivity. This may involve the transformation of traditional methods of cultivation under subsistence pressure farming into a more viable system of agricultural production processes based on modern technology. Experience shows that the productivity of land can be increased by growing crops which have higher yield potentials, raising cropping intensity and shifting the pattern of cultivation from single cropping to multiple cropping. The factors of production which directly contribute to raising the productivity of land include assured irrigation and biological and chemical technologies. The advances in these technologies centre around the adoption of HYV which will increase the yield per acre of land area, cropping intensity and multiple cropping pattern.

The HYV technology was introduced during the mid sixties. But the expansion of the HYV has been rather sluggish. Up to 1984-85 the total HYV area under rice was only 21 percent of the total cropped area (BBS 1986). The diffusion of HYV technology did not help in achieving a breakthrough in foodgrain output and it was accompanied by a lower rate *of* output growth compared to the years immediately before the introduction of HYV. There also lies a big gap between the actual and potential yield rate of HYV.

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The slow rate of expansion of HYV technology throws up some issues which are of great concern to the national planners, economists and agricultural researchers. Some studies have been conducted to examine the adoption pattern of modern technology. The studies have used farm level data (Ahmed 1980, Hossain 1989). This study examines the adoption pattern of modern technology by analyzing district level cross- section data. The main objective of the present paper is to identify the factors which affect the wide scale diffusion of HYV adoption in Bangladesh.

II. METHODOLOGY AND DATA

The data and the equation

For this study the old district level cross-section data on HYV area, farm size, tenancy, literacy, net cropped area per extension agent were considered. For this study all the data except the data on net cropped area per extension agent were obtained from various publications of the Bangladesh Bureau of Statistics (1977, 1981 and 1984) for the ¯year 1980-81. The data on net cropped area per extension agent were obtained from the Graduate Training Institute, Bangladesh Agricultural University, Mymensingh

To get maximum benefit from modern inputs such as fertilizer and HYV seed, irrigation is of vital importance. These inputs have higher productivity in irrigated land. Therefore, percentage of area irrigated to total area is taken as a variable representing the availability of the water.

Since the large farmers have easy access to information and are better able to bear the risk, in order to test the hypothesis that large farmers accept technological innovations more readily the average farm size is taken as an explanatory variable in the equation.

In order to test the hypoth3sis that share tenancy system hinders agricultural development, the tenancy variable had to be used. The variable has been defined as the percentage of total area of rented land to total cultivated land.

Literacy rate can be considered as an important factor to the receptivity of social change. It can also be considered as an input. Hence the rate of growth of output is dependent on the change of this variable. Literacy rate may be defined as percentage of rural male population of 25 years of age and above

whohave 5 years schooling and above. The Idea in defining the literacy variable as above is that the farmer with relatively high level of education is eager to adopt productive innovation earlier than the farmer with relatively little education.

Extension imparts information which is specific to the subject matter of interest of both the farmer and the extension worker at a particular time. As technology changes the subject matter also changes. Every year new varieties of rice, wheat, etc., and new bundle of inputs are coming out from research stations. So the information imparted in one year may become obsolete after some years. Formal education thus in combination with the information transmitted by the extension service enhances the farmers' ability and quality of labour and management input. Therefore, net cropped area per extension agent is considered as an explanatory variable in this study.

For performing the econometric analysis it is important to identify the variables which should be placed as endogenous variable and those should be placed as exogenous variables. Since using more fertilizer or adopting more HYV seed are the simultaneous decision of the farmers so regressing one variable on the other will give biased and inconsistent result. The test based on these regression coefficients will not bring out underlying factors responsible for the variation and a high value of R^2 in such cases will just give the complementarity in innovations (Feder *et al.* 1981)

So in performing econometric test both fertilizer use and HYV innovation have been considered as dependent variable in separate regression. In Bangladesh provision of irrigation is still dependent on farmers' individual choice. So irrigation variable has been considered as independent variable[1].

When the dependent variables have values between 0 and one (0 to 100 in percentage terms) linear regression entails some specification bias and may produce wrong prediction outside the interval. Since in our case the observed range of variation is much smaller in the district level data the problem of misspecification is probably less acute. However, we have also tried logit model which satisfies the boundness condition for the dependent variable (Gujarati 1988). The coefficient can be estimated by ordinary least square method after performing logarithmic transformation. Compared to

the ordinary linear regression the results that we have supplied, there was no systemic variation in the value of R^2 and the significance of coefficients was not effected in most cases.

To explain the observed pattern of adoption the following models were estimated by using the linear multiple regression technique to identify the factors that affect the farmers decision to adopt HYV or not. Another model was also estimated taking fertilizer use as dependent variable to identify the factors responsible for the variation in fertilizer use :

$V_1 = f(V_2, V_3, V_4, V_5, V_6)$ ... ... (1)
$V_7 = f(V_3, V_4, V_5, V_6, V_8)$ ... ... (2)
$V_9 = f(V_3, V_4, V_5, V_6, V_{10})$ ... ... (3)
$V_{11} = f(V_3, V_4, V_5, V_6, V_{10})$ ... ...(4)

where V_1 = Gross boro HYV area as a percentage of total rice area.
V_2 = Gross boro rice irrigated area as a percent of total rice area.
V_3 = Average farm size per district.
V_4 = Total rented land as percent of total cultivated land.
V_5 = Net cropped area per extension agent in a district.
V_6 = Percentage of rural male population over 25 years of age having more than 5 years of schooling based on 1981 population census data.
V_7 = Gross rice HYV area as a percentage of total rice area.
V_8 = Total rice irrigated area as a percentage of total rice cropped area.
V_9 = Gross HYV area as percentage of total cropped area.
V_{10} = Gross area irrigated as percentage of total cropped area.
V_{11} = Fertilizer used per acre in pounds.

III. RESULTS AND DISCUSSIONS

The results of multiple regression analysis are supplied in table 1. Equations 1 and 2 represent the results which are based on total cropped area. Since more than 80 percent of total cropped area are devoted to rice, equation 3 and 4 represent the results of total rice only. Since adoption rate of HYV is much higher in boro season and shows more regional variations it is also worthwhile to analyze the data for boro season. Moreover, the application of modern irrigation in this season is higher than any other season. Equations 5 and 6 represent the results for boro season only.

Table 1. Determinants of Adoption of HYV Rice

Independent Variable	Dependent Variable					
	V_9		V_7		V_1	
	1	2	3	4	5	6
V_2					0.46[a]	0.41[a]
					(3.77)	(2.99)
V_3	-2.06	-6.92[b]	1.27	-8.85[c]	-1.48	-3.03[b]
	(0.72)	(2.50)	(0.30)	(1.88)	(1.29)	(2.80)
V_4	0.63[c]	0.97[b]	0.69	1.43[b]	0.20	0.31[b]
	(2.01)	(2.80)	(1.58)	(2.59)	(1.72)	(2.57)
V_5	-4.20[b]		-7.59[a]		-1.20[b]	
	(2.79)		(3.92)		(2.37)	
V_6	-0.22	-1.30	-0.47	-3.16	0.13	-0.26
	(0.14)	(0.71)	(0.21)	(1.06)	(0.22)	(0.39)
V_8			1.29[b]	0.87		
			(2.79)	(1.39)		
V_{10}	1.18[a]	1,07[a]				
	(3.90)	(2.98)				
Constant	22.96	24,77	25,97	39,67	8,55	10,00
R^2	0,80	0,68	0,80	0,80	0,86	0,80

a This number is significant at the 0,01 level,
b This number is significant at the 0,05 level,
c This number is significant at the 0,10 level,
Figures in the parentheses indicate the corresponding t-values,

As expected irrigation has a strong positive effect on HYV adoption. In equation (1) irrigation is found to be significant at 1 percent level of significance whereas farm size shows negative sign but insignificant. Since farm size and extension agent are highly correlated in our equation net cropped area per extension agent picks up much of the effect of farm size. Therefore, excluding extension variable in equation (2) farm size becomes significant at 5 percent level of significance. The net cropped area per extension agent

shows expected negative sign and comes out to be significant at 5 percent level. Effect of tenancy is found to have positive impact on HYV adoption which is contrary to popular hypothesis (Hossain 1980)[2].

The results of other four equations are more or less similar as obtained in equations (1) and (2), Farm size shows negative sign. The net .cropped area per extension agent becomes significant at 5 percent level of significance in equation (3) and tenancy variable becomes significant at 5 percent level of significance in equations (4) and (6) respectively,

Interpretation of Results

The results obtained so far by regression analysis deserve some justifications. There are so many factors (socioeconomic and agronomic) that are responsible for the adoption rate of HYV, Due to non availability of cross section districtwise data we have included only some of the variables. The explanatory power of these variables are highly satisfactory. The effect of firm size deserves particular attention. It is an established fact that with the availability of institutional support the big farmers lead to the small farmers to the adoption of HYV in the initial years. Since facilities to irrigation by public agencies where the large farmers have easier access than small farmers the coefficient of irrigation in the regression results picks up some favourable effect on HYV adoption by large farmers. On the other hand, the coefficient of farm size reflects the effect of subsistence pressure in the case of small farmers. It should be noted that a negative correlation between farm size and adoption does not provide any conclusive remarks to the adoption rate of HYV. It merely reflects the effect of socio-economic factors that hinder the large farmers and induce the small farmers to adopt HYV. Moreover, the requirement of labour for HYV is higher than local variety. So the peak season labour shortage is an impediment to HYV adoption (Harris 1972). So the negative coefficient of farm size picks up the effect of peak season labour shortage faced by large farmers. There is also indirect evidence that the peak season labour shortage is not a serious problem for the adoption of HYV in Bangladesh. Although not to a large extent, labour storage may induce the large farmers to mechanize cultivation. .Although the wage rate is higher in peak seasons but the trend of real wage

rate declined from the late sixties (Mahmud 1983). In consideration of profit the net return from HYV is highly profitable for large farmers who depend on hired labour.

The positive effect of tenancy on the adoption of HYV is rather unexpected and needs some explanation. From the limited available empirical work Lipton (1978) observes there does not lie any consistent relationship between HYV adoption and tenancy. The available literature also does not throw much light on this issue (Adam and Rask 1968, Bardhan and Srinivasan 1971 Bhaduri 1973, Newbery 1975, 1976 Ghose and Saith 1976, Ip And Stahl 1978, Reid 1975 and 1976). The effect of tenancy is not systematically studied by controlling the effects of other variables (e. g farm size, excess to inputs, etc,). In the context of our regression analysis one may, however, think of some plausible explanations for a positive effect of tenancy on HYV adoption. It is evident from 1977 agricultural census that middle farmers (2. 5 acres to 7. 5 acres) account nearly 60 percent of all rented land from less innovative large farmers. Therefore, it is quite likely that these middle farmers get incentive to adopt HYV due to the reason that they are less handicapped by the so called supervision cost (compared to large farmers) and suffer from less severe resource constraints (compared to small farmers). It should be remembered that our result relates to positive effect of tenancy on HYV adoption, does not necessarily challenge the so called inefficiency of the institution of share tenancy. It just explains under the present agrarian structure that prevails in Bangladesh tenant farmers for their survivability get incentive to adopt HYV by using some inputs, mainly excess family labour with which they are blessed.

The coefficient of literacy in our regression is found to have insignificant impact on HYV adoption. This is not unlikely since vast majority of the small farmers are illiterate. The literacy variable as defined is not of much concern to them.

Lastly, the coefficient of net cropped area per extension agent is found to have significant effect on adoption of HYV. The sign of the coefficient is negative in all three sets of equations which is expected. In the year 1980 there were in total 4438 agricultural extension agents in Bangladesh. So,

one extension worker had 4767 acres of cropped land in his jurisdiction. Therefore, it is rather practically impossible for single extension agent to render service to the farmers for such a large area.

Results on Fertilizer use

Districtwise cross-section data on per acre fertilizer use have been analyzed to see the factors responsible for the rate of adoption of per acre fertilizer use. Table 2 represents the results of multiple regression analysis. From the equations it is evident that irrigation is found to be the most important explanatory variable to the total variation in fertilizer use, Effect of farm size is found to have insignificant effect on the use of fertilizer. This rather a slight indirect support for the small farmers to use more fertilizer to HYV which is not unlikely due to the survivability of the small farmers. The effect

Table 2, Determinants of Fertilizer Use

Independent Variable	Dependent Variable V_{11}			
	1	2	3	4
V_3		5,98	—4,95	
		(0.81)	(0,72)	
V_4		—2.02[b]	—1,25	—1,65
		(2,50)	(1,46)	(2.51)
V_5		—9,46[b]	7,31	—7.57[b]
		(2,43)	(1,60)	(2,47)
V_6		9,74[b]		8,26[b]
		(2,34)		(2,30)
V_{10}	3,32[a]	3.63[a]	3,40[a]	3,35[a]
	(4.11)	(4,97)	(3,82)	(4,87)
Constant	18,86	5,07	9,15	25,98
R^2	0,48		0,65	0,74

a This number is significant at the 0,01 level.
b This number is significant at the 0.05 level.
c This number is significant at the 0,10 level.
Figures in the parentheses indicate the corresponding t-values.

of tenancy is found to have significant effect in equation (2) and (4) and shows the expected negative sign. This may be a contradiction to the effect of tenancy on HYV adoption. The rate of use of fertilizer among the small farmers is very low due to the financial constraint faced by them. The insignificance of farm size only reflects the effect that with the limited resources the small farmers try to use more fertilizer to HYV to get maximum benefit from HYV for their survivability. As expected, literacy has a significant positive impact on fertilizer use. The net crppped area per extension agent shows the expected sign in all the equations and comes out to be signicant at 5 percent level. This indicates that it is impossible for a single extension agent to supervise such a large area and to induce the farmers to use more fertilizer. Further, there lies variation in both macro and micro nutrient contents in soils in different areas of Bangladesh and it is not possible for the extension agents to suggest proper dose of fertilizer to the farmers for different crops (Table A2. in Appendix). In order to popularize the adoption of HYV the number of field level extension agents should be sufficiently increased in all the districts.

IV. CONCLUSION

From our empirical analysis and discussions made so far the following observations can be made from the study :

Of all the variables considered, irrigation comes out to be more important for the unequal distribution of HYV in Bangladesh. Therefore, for the efficient use of the water resources, source, amount and quality of water resources for irrigation purpose should be properly estimated. Irrigation schedule should be maintained properly. Strong coordination between the technical personnel and other staff of the politico-bureaucratic structure of Upazila engaged for the agricultural development is of vital importance not only in paper but also in practice for the present stage of agricultural development. An immediate step towards enactment of proper legal provisions regarding irrigation, based on both socioeconomic and technical aspects, will probably fulfill the desired goal.

Economic factors like fertilizer has significant impact on the regional differences in the HYV adoption in Bangladesh. Due to soil fertility differ-

ences in different areas of Bangladesh, the appropriate fertilizer doses would vary across regions. The present system of recommending the doses of fertilizer for different crops after proper soil testing does not take into account these regional differences. Recommended fertilizer doses should be specific to different regions.

The field level extension agents should be increased in sufficient number. The present approach of extension through Training and Visit system should be modified. The approach should be directed to groups of farmers which will include farmers from large, medium and small groups as well as landless.

NOTES

1. This is due to the small size and excesive fragmentation of land holdings,
2. Since the incidence of tenancy may be positively related to farm size one may suspect multicollinearity in this case. In our case the correlation coefficient between tenancy and farm size is only 0,37 which is insignificant,

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APPENDIX

Table A-1. District Level Data Used in the Regression Equation.

District	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
Chittagong	25.00	24.00	2.74	30.56	1.59	7.61	70.00	28.00	63.00	28.00	118.00
Chittagong Hill Tracts	11 00	12 00	4 85	26.46	2 51	5.16	64.00	12.00	42.00	12.00	44.00
Comilla	12.00	13.00	1.96	9.97	3.61	7.35	36.00	15.00	36.00	15.00	108.00
Noakhali	9 00	10.00	2.87	30.66	3.93	7.74	45.00	13.00	40.00	12.00	53.00
Sylhet	7.00	24.00	4.03	15.21	7.21	4.68	15.00	24.00	14.00	22.00	23.00
Dhaka	13.00	15.00	2.71	14.67	2.70	7.18	27.00	18.00	22.00	16.00	97.00
Faridpur	4.00	4.00	3.31	17.10	4 57	6.97	6.00	5.00	7.00	4.00	18.00
Kishoregonj	5.00	7 00	3.64	17.90	3.03	5.82	17.00	8.00	15.00	9.00	39.00
Mymensingh	7.00	19.00	3.29	13.78	4.25	5.83	37.00	22.00	32.00	10.00	83.00
Tangail	10.00	11.00	3.24	19.49	3.46	7.14	16.00	11.00	16.00	12.00	61.00
Barisal	6.00	7.00	3.78	32.01	4.62	9.20	16.00	12.00	14.00	10.00	30.00
Jessore	2.00	1.00	4.23	14.23	5.62	8.19	11.00	6.00	9.00	8.00	48.00
Khulna	2.00	4.00	4.31	23.36	4.84	10.19	13.00	6.00	13.00	7.00	27.00
Kushtia	1.00	1.00	4.62	14.33	5.36	5.30	16.00	14.00	24.00	24.00	108.00
Patuakhali	0.01	0.01	6.20	34.57	6.28	7.49	6.00	3.00	6.00	3.00	15.00
Bogra	6.00	6.00	3.12	15.15	3.00	8.79	25.00	9.00	27.00	19.00	119.00
Dinajpur	1.00	1.00	4.75	19.88	6.24	8.17	9 00	4.00	17.00	8.00	51.00
Pabna	3.00	4.00	4.12	16.40	5.20	6.72	5.00	6.00	10.00	7.00	52.00
Rajshahi	5.00	6.00	4.41	20.76	6.44	7.18	8.00	10.00	12.00	13.00	61.00
Rangpur	3.00	3.00	3.51	15.15	4.48	7.25	14.00	12.00	18.00	10.00	38.00

Sources : Column 3 and 4 Report on the Agricultural Census of Bangladesh, 1977 (National Volume).
Column 5, Graduate Training Institute, Bangladesh Agricultural University, Mymensingh.
Column 8, Bangladesh Population Census, 1981.
All other columns, Statistical Year Book of Bangladesh, 1983-84 and Agricultural Year Book of Bangladesh 1983-84.

Notes : The variables are explained in the Text.
Data of Jamalpur district is included in Mymensingh district.

Table A-2. Analytical Data of Some Important Soil Series of Bangladesh.

Series	pH	O.M. %	A.A.	Ca	Mg	K	P	S	B	Cu	Fe	Mn	Zn
			(med/100 ml soil)				(ug/ml soil)						
Gangachara	5.6	1.3	0.0	2.7	0.7	0.14	14.0	4.0	0.29	3.4	151.0	22.1	0.7
Palashbari	5.6	1.3	0.1	3.8	1.2	0.08	14.0	4.0	0.29	5.6	151.0	34.3	1.0
Kaunia	5.9	0.8	0.0	4.1	1.09	0.01	0.01	3.0	7.00	0.35	5.4	214.0	39.4
Debiganj	5.1	0.4	0.3	0.7	0.18	0.06	4.0	3.0	0.39	0.1	27.0	2.2	0.7
Lauta	4.6	1.4	1.2	8.5	2.9	0.26	19.0	75.0	0.74	8.2	310.0	40.3	3.5
Amnura	5.5	0.9	0.0	8.5	2.6	0.31	21.0	8.0	0.14	7.8	214.0	12.5	1.8
Nachole	6.3	1.3	0.0	14.0	4.0	0.27	12.0	8.0	0.44	9.5	159.0	31.8	1.7
Ishurdi	7.9	1.3	0.0	13.0	3.0	0.17	7.0	4.0	0.74	6.3	22.0	3.8	1.0
Sara	7.9	0.9	0.0	5.5	2.5	0.15	16.0	4.0	1.20	2.2	22.0	14.6	1.0
Ghior	6.8	2.1	0.0	20.0	6.1	0.34	9.0	10.0	0.29	5.8	31.0	11.2	1.0
Gopalpur	7.7	1.4	0.0	16.2	4.0	0.22	10.0	4.0	1.52	10.8	22.0	4.6	1.5
Kushtia-1	6.1	1.2	0.0	16.2	5.09	0.22	13.0	28.0	0.55	7.8	151.0	83.4	1.3
Darsana	7.0	0.5	0.0	19.8	4.68	0.22	2.0	3.0	0.35	3.4	30.0	7.4	0.8
Jessore-1*	7.5	0.3	0.0	18.3	4.36	0.15	1.0	3.0	0.55	1.7	18.0	4.0	1.1
Khulna-2*	7.7	1.1	0.0	13.9	3.45	0.26	35.0	15.0	0.65	6.0	128.0	6.3	4.8
Khulna-1*	7.8	1.0	0.4	13.9	3.94	0.15	7.0	61.0	1.74	6.6	68.0	7.6	1.7
Nandina	6.2	0.8	0.0	5.2	1.9	0.05	5.0	9.0	0.70	4.8	123.0	17.8	0.5
Kashimpur	5.6	1.3	0.0	6.0	2.1	0.78	33.0	38.0	0.59	4.6	136.0	24.6	7.8
Chhiata	5.3	0.6	0.3	12.8	5.7	0.12	5.0	4.0	0.59	3.4	31.0	38.2	1.0
Burichong	5.2	1.7	0.2	6.6	2.38	0.22	35.0	15.0	0.63	6.4	374.0	97.6	1.3
Tippera	4.8	0.7	0.3	1.4	0.63	0.06	33.0	2.0	0.22	2.2	226.0	4.7	0.8
Devidwar	5.3	1.0	0.3	2.7	1.33	0.11	18.0	4.0	0.53	4.6	243.0	22.0	0.9
Miresharai	5.2	0.8	0.1	4.2	2.82	0.10	20.0	6.0	0.42	4.7	187.0	72.8	1.4
Pahartali	5.2	0.8	0.1	2.9	1.93	0.05	12.0	2.0	0.49	3.5	150.0	34.4	1.3
Srimangal	4.0	1.3	2.9	0,01	0,22	0,03	2.0	23,0	0,14	2,9	194,0	1,0	1,4
Critical level				2,0	0,8	0,2	14,0	14,0	0,2	1,0	10,0	5.0	2,0

Source: S, Islam, *et al*, (1985),

Table A-3 : Correlation Matrix Showing Interrelationships among the Selected Variables

HEADER DATA FOR : B : ERSI LABEL : L1
NUMBER OF CASES : 20 NUMBER OF VARIABLES : 7

	V2	V3	V4	V5	V6	V8	V10
V2	1.00000						
V3	-.51826	1.00000					
V4	-.02769	.37843	1.00000				
V5	-.37889	.60445	-.06802	1.00000			
V6	-.37096	-.08540	.30060	-.04552	1.00000		
V8	.90681	-.50113	-.07911	-.33597	-.38773	1.00000	
V10	.59718	-.36859	-.13356	-.29907	-.28085	.77183	1.00000

CRITICAL VALUE (1-TAIL, .05) = + or — .37911
CRITICAL VALUE (2-tail, .05) = +/- .44260
N = 20