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THE ECONOMICS OF INVESTMENT IN AGRICULTURAL RESEARCH IN BANGLADESH

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ABSTRACT

The benefits of agricultural research are examined in an ex ante consumer-producer surplus framework for four agricultural sub-sectors-crops, livestock, forestry and fisheries-and for the agricultural sector as a whole in Bangladesh. The results are based on the analysis of data obtained from 240 researchers of Bangladesh agricultural research system and other secondary sources. The projected internal rates of return to research indicate substantial returns to public investments. The analysis reveals that government continues to underinvestt in agricultural research and that scope remains for the government and donors to invest more.

I. INTRODUCTION

Agriculture is the largest single sector of the Bangladesh economy and accounts for nearly half of the gross domestic product (GDP). It employs around 60 per cent of the labour force of the country. Hence, the overall economic development of the country depends largely on the performance of the agricultural sector. If agriculture is to play a major role in economic development, the productivity of factors of production used in agriculture (land labour and capital) must be increased. Because of limited land base, the development of new technologies by means of agricultural research is essential' to achieve these productivity increases (Mellor 1987). Research increases agricultural productivity in several ways- by raising returns to factors of production through lowering costs or increasing output, by improving product quality or introducing new products, and by reducing the cultivators vulnerability to forces beyond his control (Arndt and Ruttan 1976). So, agricultural research must be considered as an integral part of agricultural development and should not be taken as a separate entity to be carries out at isolated research stations. It links back into the national planning and forward to serve the farmers.

There is a general agreement that the efficient application of agricultural research is one of the primary means for accelerating the rate of agricultural

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development in developing countries, and for maintaining this rate in the more advanced nation. The future of agricultural development thus depends to a large extent on the research activities that are undertaken, and these in turn ate dependent on the amount of financial resources which governments and other public bodies are prepared to invest.

To allocate sufficient amount of resources to agricultural research, decision makers require information on the pay-off of agricultural research since it competes with alternative uses of public funds. This paper tries to

(i) estimate return to investment in agricultural research and

(ii) discuss policy implications for Investment in public agricultural research

The paper consists of five sections. The second section reviews the studies that have concentrated on research impacts in Bangladesh and in other countries. Section III shows the returns to agricultural research in Bangladesh. Comparison of investment in agricultural research in Bangladesh and in other countries is presented in section IV. Conclusions are made in the last section.

II. REVIEW OF STUDIES ON RETURN TO RESEARCH

In this paper we are concerned with aggregate return to research. The rates of return to research in aggregate agricultural production, provide a more realistic measure of research investment because the process often involves the simultaneous exploration of problems that concern a large number of commoditles. Research leads to "deadends" as well as "breakthrough" and thus not every specific research project has a positive rate of return. We are more interested to know whether overall activity has a high average pay off to society.

This section reviews the studies dealt with the return to research in crop, livestock and aggregate agricultural production in different countries. Table 1 summarises the study results and their analytical technique. These studies used thrae types of analytical techniques - Imputation Accounting Method (IAM), Statistical Meta-Production Function (MPF), and Total Factor Productivity Decomposition Studies (DS).

The estimated internal rates of return to investment for IAM studies is the average rates of return over the entire period. IAM studies have typically measured the combined producers and consumers surplus distributable to the

Table 1. Estimated Return to Public Sector Research in Different Countries.

Study	Country	Analytical technique	Time period	Estimated Annual Internal Rate of Return (%)
		Aggregate		
Peterson and Fitzharris, 1977	USA	IAM	1937-1942	50
			1947-1952	51
			1957-1962	49
			1967-1972	34
Pray, 1978*	Punjab (British India)	IAM	1906-1956	34-44
	Punjab (Pakistan)		1948-63	23-37
da Crutz and Avila, 1983	Brazil	IAM	1977-1982	20
Tang, 1983	Japan	MPF	1880-1938	35
Griliches, 1964	USA	MPF	1949-1959	35-40
Latimer, 1964	USA	MPF	1949-1959	not significant
Evenson, 1968	USA	MPF	1949-1959	47
Cline, 1975 (revised by Knutson and Tweeten, 1979)	USA	MPF	1939-1948	41-50[a]
Kahelon, Bal, Saxena, and Jha, 1979	India	MPF	1960-1961	63
Davis, 1979	Canada	MPF	1949-1959	66-100
			1964-1974	37
Pray and Ahmed. 1990	Bangladesh	MPF	1948-1981	100+
White and Havlicek, 1982	USA	MPF	1943-1977	36
Evenson. 1979	USA	DS	1868-1926	65
Evenson, 1987	India	DS	1959-1975	100+
Evenson and Jha, 1973	India	DS	1953-1971	40

Table 1. Continued

Nagy, 1990	Pakistan	DS	1959-1979	64.5
Evenson, 1982	Brazil	DS	1966-1979	69
Silva, 1984	Brazil	DS	1970-1980	60
Huffman and Evenson. 1989	USA	DS	1950-1982	
			Applied	43
			Pre-Tech	67
		Crop		
Barletta, 1970	Mexico	MPF	1943-1963	45-93
Evenson and welch, 1979 (Crop & livestock)	USA	MPF	1964	55
Fox, 1986	USA	MPF	1944-1983	
			Applied	180
			Science	180
Huffman and Evenson, 1989	USA	DS	1950-1982	
			Applied	45
			Pre-Tech	67
Dey and Evenson	Bangladesh	DS	1973-1989	143e
		Livestock		
Bredahl and Peterson, 1976	USA	MPF	1969	47[b]
For, 1986	USA	MPF	1944-1983	
			Applied	150
			Science	116
Norton, 1980	USA	MPF	1974	81
Huffman and Evenson,1989	USA	DS	1950-1982	
			Applied	11
			Pre-Tech	83

Source : Evenson (1990), pp. 53-63.

Note : a. Lower estimate for 13 and higher estimate for 16 year between begining and end of output impact.

b. Lagged marginal product of 1969 research on output discounted for estimated mean lag of 7 years.
c. Star marked (*) studies dealt with aggregate impact of agricultural research and extension.
d. IAM, MPF and DS stands for Imputation Accounting Method, Statistical Meta-Production Function and Decomposition Studies, respectively.
e. For rice, wheat, Jute, Potato, sugarcane, pulses and oilseeds

aggregate research (and in two cases extension & research) programme. Results show that the estimated annual internal rate of return to investment in agricultural research system was 20 to 51 per cent which imply that return to research investment is quite reasonable.

Statistical Meta—Production Function (MPF) studies used statistical methods. These studies measured the linkage between investments (i. e. inputs) in research and productivity using aggregate production function analysis incorporating research variables. The estimated rate of return from these studies can be roughly interpreted as the returns to "marginal" investment. They ware calculated by computing the estimated marginal product of the research variable and taking into account the time weights entailed in the estimates. The results show that the estimated annual rate of return to investment in total agricultural research in USA varies between 35 to 50 per cent in different time periods, but it was 35 and 63 in Japan and India, respectively. Estimated annual rates of return to investment in research on crop sector varies from 45 per cent to 180 per cent and the figures for livestock research varies from 47 per cent to 150 per cent. In Bangladesh, the estimated internal rate of return to investment in total agricultural research between the period 1948-1981 was more than 100 per cent.

Total Factor Productivity Decomposition Studies (DS) used two stage analysis. They first computed a total factor productivity index using observation specific weights and then decomposes the change in productivity among various sources. The results of these studies show that estimated annual rate of return to aggregate research in different countries in different time periods ranges from 40 to more than 100 per cent. The estimated figures for crop sector varies between 45 to 67 and the figures lies between 11 to 83 per cent for livestock sector. A recent study (Dey and Evenson, 1991) shows that in

Bangladesh the estimated internal rate of return to crops (rice, wheat, potato, jute, sugarcane, pulses and oilseeds) research for the period of 1973 to 1989 was143 percent.

Some other studies (Pray, 1979; Alauddin, 1982 and Gill. 1982) have also attempted to measure the return to investment in agricultural research in Bangladesh. Pray (1979) used index number apprach to estimate previous benefit from research (ex-post analysis). The study showed an estimated rate of return of over 30 per cent for the investment in agricultural research system even after substracting benefits from Pajam and part of benefits from MVs developed by the international agricultural research centers like IRRI and CIMMYT.

Alauddin (1982) is also a ex post study of previous benefits from research. He estimated that the marginal product of research investment was 23 takas for cash taka invested. Gill (1982) estimated the future impact of new technologies produced by oilseeds, pulses and soil scientists. He projected a rate of return cf 90 per cent and over 300 per cent for the investment in developing new varieties of oilseeds and summer pulses respectively.

Discussion of this section shows that IRR is high for investment in agricultural research both in developed and developing countries. But only a few studies have been conducted on the aggregate return to agricultural research in Bangladesh. In addition, all prior studies have been ex-post and have ignored the effect of government policies and of demand shifts.

Ex-post studies evaluate completed research projects and estimate returns based on past performance. But it was productive fn the past does not mean that it will be productive in the future. Ex-ante studies of return to research use information on the projected yield, cost of production and rate of adoption, and estimate, benefits from research.

III. RETURN TO AGRICULTURAL RESEARGH IN BANGLADESH: AN EX-ANTE ANALYSIS

The current study examine the benefit of agricultural research using ex-ante economic surplus technique. It extend previous studies on return to research in Bangladesh by considering the effect of demand shifts, the influence of government policies, and by using different formula for different commodities.

Furthermore, this is the first ex-ante analysis on the aggregate return to the investment in agricultural research in Bangladesh. This study has synthesised the information provided by both the physical and social scientists. As a result reliability of the estimates has been increased.

Estimation Procedure :

The basic model used in the study is shown in Figure 1 for the non-traded commodities :

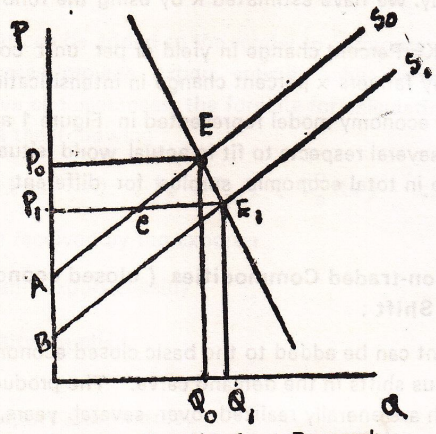

Figure 1. Benefits from Research

The original supply curve without technological change is represented by S_0 and the demand curve by D_0 in Figure 1. The original price and quantity are P_0 and Q_0. The supply curve shifts to S_1 due to adoption of a new technology, resulting in a new price and quantity of P_1 and Q_1. The change in consumers' surplus from technological change is represented by the area $P_0EE_1P_1$ and the change in producers' surplus is represented by the area $BE_1P_1-AEP_0$. The net benefit to producers is either positive or negative depending on the magnitude of the demand and supply elasticities. The total net economic benefits (CTS) equal the sum of the changes in producers and consumers surplus :

$$CTS = P_0EE_1P_1 + BE_1P_1 - AEP_0$$
$$= P_0EE_1P_1 + ABE_1C - P_0ECP_1$$
$$= ABE_1E$$

Using formula suggested by Norton *et al.* (1991) area ABE_1E can be measured as follows :

$$CTS_t = ABE_1E = KP_0Q_0 (1 + .5 Zn) \quad \ldots\ldots(1)$$

Where, CTS = Change in total economic surplus in time period t,

K = Per unit cost reduction due to research,

Z = en/ (e+n) where e is the price elasticity of demand (absolute value).

In this study, we have estimated K by using the following formula :

K = Percent change in yield or per unit cost x rate of adoption of technology by farmers x percent change in intensification.

The closed economy model represented in Figure 1 and in equation 1 can be modified in several respects to fit in actual world situations. Formulas to measure change in total economic surplus for different situations has been given below.

Formula for Non-traded Commodities (closed economy) with Exogenous Demand Shift :

A refinement can be added to the basic closed economy model to incorporate exogenous shifts in the demand curve. The production effects of agricultural research are generally realized over several years. Thus, changes in demand, which occurs due to changes in population and income over time, would substantially affect the market of non-traded commodities. In that case, the new change in total net economic surplus is

$$CTS = KP'_0Q'_0 (1 + .5 Zn) \quad \ldots\ldots(2)$$

Where, $P'_0 = P_0 [1 + v / (n + e)]$

$Q'_0 = Q_0 [1 + v - vn / (n + e)]$

v = Proportionate shift in demand at original P and Q

Formula for Small Export or Import Commodity :

A second refinement incorporates the fact that Bangladesh imports or exports as a small importer or exporter, some of the commodities for which new technologies are being developed. Since small importer or exporter cannot affect the world price, a shift out in the supply curve due to technological

change will not change the market price. The formula for calculating the changes in economic surplus for either the small importer or the exporter is the following :

$$CTS_t = KP_w Q_o (1 + .5 K e) \quad \ldots\ldots(3)$$

Where P_w = Bo rder price of the commodity

Formula for Small Export Commodity with Export Subsidy:

A third refinement can be added to the model to incorporate the fact that Bangladesh in some cases provide export subsidy while acting as a small exporter. In the above circumstances, the formula for calculating the changes in economic surplus is the following :

$$CTS_t = KP_* Q_s^o (1 + .5 Ke) - (P_* - P_w)(Q_s^o Ke) \quad \ldots\ldots (4)$$

Where, P_* = Price received by the exporter

$(P_* - P_w)$ = Per unit export subsidy

Q_t^o = Initial quantity supplied.

Formula for Large Export Commodity :

A final model modification considers the fact that Bangladesh is a large producer of jute in the world market, and jute production in Bangladesh affects world price of jute. Part of the gains (or losses) from a shift in the supply curve of jute will be realized in other countries. In this case, the changes in total economic can be measured as follows :

$$CTS_t = gP_o Q_D^o (1 + .5 gn) + (KP_o Q_s^o - gP_o Q_s^o)(1 + .5Ke) + .5P_o Q_s^o eg (g - k) \quad \ldots\ldots (5)$$

Where, $g = Lr/(r + X)$

$$L = (KeQ_s^o / Q_{tt}^o)/r$$

Q_D^o = initial quantity demanded

Q_s^o = initial quantity supplied

Q_T^o = initial quantity traded

r = excess supply elasticity in Bangladesh

x = excess demand elasticity in the rest of the world

The formulas described earlier assumed parallel shift of the supply curve. Shift of the supply curve may be parallel, divergent and convergent, and the results would vary depending on the assumption made (Linder and Jarrett, 1978). But it is extremely difficult to predict the nature of the industry supply shifts. In the absence of the necessary information in choosing a particular type of shift, we have assumed parallel shifts.

In Bangladesh, research is being conducted on a large number of commodities. Discussion with research administrators of the National Agricultural Research System revealed that country would get benefit in near future (with in 15 years from now) from agricultural research on 57 commodities/commodity groups. Total economic benefit from research has been calculated for each of these commodities / commodity groups by using formula described above and total return to research in Bangladesh has been estimated by adding these benefits. In determining return, we estimated benefits which could be obtained from an investment of 5 years period.

Data Collection :

Data for expected per unit cost reductions and yield increase, probabilities of research success, and expected level of adoption of research results were collected from 240 agricultural researcher of the Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRI), Bangladesh Jute Research Institute (BJRI), Sugarcane Research and Training Institute (SRTI), Bangladesh Livestock Research Institute (BLRI), Bangladesh Forest Research Institute (BFRI), Fisheries Research Institute (FRI) , Bangladesh Tea Research Institute (BTRI), Bangladesh Institute of Nuclear Agriculture (BINA) & Bangladesh Agricultural Research Council (BARC). A set of questionnaires were used in interviewing scientists and extension workers. In addition, a worksheet was used for each group of commodities to facilitated questioning accross several commodities during the interviews. Level of adoption data was reviewed by officials of the Department of Agricultural Extension. Data were gathered from published sources (Bangladesh Bureau of

Siadsia and Ag. marketing Directorate) for quantity of production, exports, imports, and prices. Information about elasticities, government price policies and demand shifts were collected ftom different secondary sources and from economists knowledgeable about particular commodities. Data used in the analysis have been given in the Appendix.

Results:

The formulas, data, and assumptions described above were incorporated in LOTUS programme. Total economic surplus gains minus research cost and internal rates of return were calculated (Table 2). We used 1990 as a beginning year of our analysis. Changes in yields or per unit costs determined by asking the scientists to estimate expected per unit cost reduction or yield increase due to their research over the next 5 years at the present level of investment. Thus, here we kept the real yearly expenditure in research constant for the 5 year period. Yearly nominal expenditure is assumed to increased by 10 percent only to cover 10 percent annual inflation. In calculating sector wise expenditure, expenditure on BARC has been divided among different sectors proportionately. Two scenarios are presented for calculating internal rate of returns. Under first scenario, 15 years time period is assumed to calculate benefit streams. Under second scenario, benefit streams are calcuIsted for 10 years only.

Table 2 shows that internal rate of return to investment in agricultural sector in Bangladesh is 90 per cant. The results imply that Bangladesh earns Tk. 190 by investing Tk. 100 in agricultural research. Even if we use 10 yoars benefit stream, IRR would be 88 per cent. These estimated rates of return ate compareable to the rate of return obtained in a recent ex-post studies (Dey a.1d Evenson, 1991). Dey and Evenson (1991) estimated that the internal r3te of return to the investment in crops research were 143 per cent. However, Day and Evznson (7991) has considered only rice, wheat, jute, sugarcane, potato, pulses and oilseeds within crops sector; and most of these crops have experienced major break through in yield. On the other hand, this study has considered 44 crops within the crops sector and some of these crops will not experience the benefits of the research in near future.

Among the various sectors, IRR is highest for the fishery sector (113%) followed by the crop sector (109%). Internal rate of return is lowest in

Table 2. Net Economic Benefits to Agricultural Research in Bangladesh. (in '000 Taka)

Year	Crop	Fisheries	Livestock	Forestry	Aggregate
1990	—453663	—82122	—108634	—102297	—746716
1991	—281512	—90334	—119497	—110546	—601890
1992	—400306	—99368	—131447	—114244	55247
1993	1455374	303968	—144592	—90445	1524305
1994	2274841	750051	—159051	—67654	2798188
1995	3844085	1374702	0	118757	5337543
1996	4700188	1906823	221207	155624	6983842
1997	5702990	2468106	472714	192723	8836534
1998	6569222	3178323	755629	200548	10703722
1999	6714143	3332508	1070432	208418	11325501
2000	6832954	3496571	1416884	216333	11962742
2001	6868405	3670699	1616081	222074	12377259
2002	6887295	3855078	1831394	222074	12795841
2003	6911946	4049895	2005442	222074	13189356
2004	6943321	4185663	2188834	222074	13539392
IRR(%)for :					
a) 15 years	109.21	113.10	39.42	20.46	89.65
b) 10 years	108.48	111.92	25.00	11.48	88.05

Source : Own Calculation.

Forestry sector (20%). It is worthwhile to mention that we have not been able to capture some intangible benefits of agricultural research, such as effect on environment, in our analysis.

IV. INVESTMENT IN AGRICULTURAL RESEARCH IN BANGLADESH : A COMPARISON WITH OTHER COUNTRIES

Resource allocation to research in Bangladesh and in some other countries of Asia as well as other parts of the world are presented in this section.

Table 3 and 4 compare the public sector research expenditure as a per cent of agricultural GDP in different countries. It is evident from table 3

Table 3. Public Sector Research Expenditure in Different Countries of the World.

Sub-region	As%of the value of agricultural product		
	1959	1970	1980
Low-income Developing	0.15	0.27	0,50
Middle-income Developing	0 29	0.57	0.81
Semi-Industrialised	0.29	0.54	0.66
Industrialised	0.68	1.37	1.50
Planned	0.33	0.73	0.66
Planned Excluding China	0.45	0.75	0.73
Northern Europe	0.55	1.05	1.60
Central Europe	0.39	1.20	1.54
Southern Europe	0.24	0.61	0.71
Eastern Europe	0.50	0.81	0.78
USSR	0.43	0.73	0.70
Ocenia	0.99	2.24	2.83
North America	0.84	1.27	1.09
Temperate South America	0.39	0.64	0.70
Tropical South America	0.25	0.67	0.98
Caribbean & Central America	0.15	0.22	0.63
North Africa	0.31	0.62	0.59
West Africa	0.37	0.61	1.19
East Africa	0.19	0.53	0.81
South Africa	1.13	1.10	1.23
West Asia	0.18	0.37	0.47
South Asia	0.12	0.19	0.43
South-east Asia	0.10	0.28	0.52
East Asia	0.69	2.01	2.44

Source ; Evenson. Yale University as cited in Choudhury 1989 P. 84.
Judd, Boyce and Evenson (1986) as mentioned in Evenson (1990)

that North American, Northern and Central European, South African and East Asian countries generally spend more than one per cent of their agricultural GDP on agricultural research. These developed and middle income develop-

Table 4. Agricultural Research Investment as Percent of AGDP in the Asian NARS.

Country	Latest Yr	Agricultural Research Expenditures as % of Agril. GDP	
		Latest yr	1980
SOUTH ASIA			
Bangladesh	1689	0.25	0.37
India	1986	1.60	0.29
Nepal	1981	0.23	0.27
Pakistan	1985	0.34	0.50
Srilanka	1982	1.50	0.42
SOUTH-EAST ASIA			
Indonesia	1983	0.27	0.31
Malaysia	1986	1.90	0.83
Philippines	1986	0.49	0.14
Thailand	1985	1.59	0.58
EAST ASIA			
China	1980	0.70	0.70
Republic of Korea	1985	0.42	0.15
Taiwan	1987	0.71	N.A

Source : For 1980 Figures Oram (1988), Table GA.:
For Latest year data — Madamba (1990);
For Bangladesh data— Own calculation.

ing countries are spending steadily increasing proportions of their national income on agricultural research.

Judd, Boyce and Evenson (1986) grouped all the countries into five categories : low income developing, middle income developing, semi-industrialised, industrialised and planned countries. The data show that lower income countries spend less their rich counter-part. Table 4 shows agricultural research investment in Asian Countries. It is evident from the table that the richer countries are spending larger proportion of their agricultural GDP on agricultural research and these proportions are incre asing over the years. But the situation in Bangladesh is different from what is happening in other developing countries. Bangladesh invests less than 0.3 percent of her

Table 5, Relationship Among Total Agricultural Research Expenditure, Gross Domestic Product (Total GDP and Agricultural GDP) and Agricultural Expenditure.

(in Million Tk.)

Year	Total agril research expen.	Total GDP	Agril GDP	Total Govt Exp	Total Agril Exp	AGDP as % of GDP	Ag. Exp. as % of Total Exp	Total Agril. Res. as % of		
								GDP	Ag. GDP	Ag.Exp
1975/76	107.13	107458	57339	13404	1306	53.36	9.74	0.10	0.19	8.20
1976/77	107.29	105361	53671	17376	1796	50.94	10.34	0.10	0.20	5.97
1977/78	154.47	130290	72248	21135	1878	55.45	8.89	0.12	0.21	8.23
1978/79	201.39	144774	18745	27926	2455	54.39	8.79	0.14	0.26	8.20
1979/80	302.81	172450	93299	33535	5065	54 10	15.10	0.18	0.32	5.98
1980/81	203.46	194847	95434	38642	4823	49.03	12.48	0.10	0.21	4.22
1981/82	347.98	265144	121839	42829	6474	45.95	15.12	0.13	0.29	5.37
1982/83	498.63	288423	135871	42630	4427	47.11	10.38	0.17	0.37	11.26
1983/84	383.40	349922	169328	50196	8130	48.39	16.20	0.11	0.23	4.72
1984/85	470.95	416962	207976	60707	9335	49.88	15.38	0.11	0.23	5.04
1985/86	467.01	466227	138382	70887	2944	40.41	4.15	0.10	0.25	15.86
1986/87	848.95	539201	219761	78415	3587	40.76	4.57	0.12	0.30	18.09
1987/88	670.77	597136	231623	88306	4583	36.79	5.19	0.11	0.29	14.63
1988/89	622.54	659598	245392	108244	4612	37.20	4.26	0.09	0.25	13.50

Note : Total agricultural research expenditure include money spent to the institutes under National Agricultural Research System (NARS).

Source : 1. Total Agricultural Research expenditure data were collected from :

a). Revised Annual Development Programme (Various Issues), Planning Commission.

b) BTRI for BTRI data upto 1988-89, 1989-90 data was estimated on the basis percentage increase in expenditure in other NARS Institutes.

c) BFRI for BFRI data upto 1988-89, 1989-90 data was collected from BARC (ISNAR).

d) For BINA & SRTI, 1985-88 to 1989-90, data was collected from BARC (ISNAR).

2. BBS, Statistical Year Book of Bangladesh (Various Issues) for total GDP, agricultural GDP; total government expenditure, and agricultural expenditure data.

agricultural GDP in agricultural research. And this share is decreasing steadily since 1986/87 (Table 5). This is really an unwanted scenario.

Table 6. Estimated Internal Rates of Return of Different Irrigation Projects / Technologies in Bangladesh .

Projects / Irrigation Technique	IRR(%)
1. Muhuri Irrigation Project	10.0
2. Meghna—Dhonagoda Irrgation Project	17.9
3. Karnafuli Irrigation Project	13.0
4. Barisal Irrigation Project	11.0
5. Chandpur Irrigation Project	5.0
6. Deep Tubewell	22.0
7. Shallow Tubewell	46.0
8. Hand Tubewell	32.0

Source : Lindquist A. C. (1980) for Sl No. 1 to 5
Hossain M. B. (1980) for Sl No. 6 to 8

Discussion in section II and section III tells us that agricultural research is not less productive in Bangladesh than in other developed and developing countries. Previous sections have also showed that Bangladesh was to increase expenditure in agricultural research in order to develop her economy.

By comparing research investment and its return figures for different countries, as shown earlier, it may be safe to suggest that Bangladesh should invest at least 1 per cent of agricultural GDP during the fourth five year plan period.

V. CONCLUSIONS

Previous ex-post studies found that agricultural research is a good investment of government resources in Bangladesh. The results of our ex-ante analysis confirm this conclusion. And the projected rates of return to agricultural research are higher than the rate of returns to investment in irrigation (Table 6). The policy implications of this study seem clear. The Bangladesh

government and the donors will receive very high returns to their investment agricultural research. The analysis also suggests that the government continues to underinvest in agricultural research. Among the alternatives by which an economy can increase its agricultural output, research is the most productive. But Bangladesh is not taking advantage of this productive sector. If Bangladesh is to meet the massive challenge of increasing agricultural production in the future, she will have to invest more in the agricultural research system.

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Appendix Table 1. Summary of Scientist Interviews

Commodity	Percent yield change	Percent prob. Success	Years to Results	Percent Adopt Rate	Peak year Adopt	Percent Intensification	Quality change
Boro+T.Aus	7.5	85	1	20	3	1	
B.Aus	20	85	3	10	5	0	
B. Aman	10	85	2	20	5	1	
T. Aman	40	85	2	16	6	0	
Wheat	20	80	4	30	7	1	
Barley	25	80	4	50	5	1	Yes
Maize	40	90	1	80	4	15	
Millet	20	90	2	30	5	0	
Lentil	20	90	2	20	7	0	
Gram	20	90	2	20	7	0	
Blackgram	20	90	2	20	7	0	
Mungbean	20	90	2	20	7	0	
Mustard & Rape	18	80	2	25	5	0	
Sesame	15	80	2	10	5	0	
Groundnut	18	80	2	25	5	5	
Coconut	80	70	3	10	2	0	
Cotton	10	80	3	75	5	1	
Jute	20	85	1	30	5	1	Yes
Tea	60	70	2	15	10	0	Yes
Tobacco	20	60	5	30	5	0	
Betelnut	10	50	5	20	7	0	
Betelleaves	7.5	60	5	30	4	0	
Potato	20	90	3	50	5	0	
Sweet Potato	50	90	1	20	4	0	
Aroids	40	90	3	30	3	0	
Chili	30	60	2	25	5	0	
Onion	30	60	2	25	5	0	
Garlic	20	60	3	25	5	0	
Turmeric	40	70	2	25	5	0	
Ginger	25	60	6	25	5	0	
Sugarcane	40	80	3	25	6	0	

Appendix Table 1. Continued

Banana	15	70	5	25	5	2	
Mango	40	70	10	30	5	1	
Jackfruit	30	70	10	30	5	0	
Pineapple	15	70	3	20	4	0	
Citrus	25	70	5	30	5	2	
Melon	10	70	1	20	5	1	
Papaya	20	70	3	30	5	1	
Brinjal	15	80	2	15	2	1	
Tomato	15	80	2	20	4	2	
Radish	7.5	80	2	50	2	0	
Cauli. & Cab.	12	80	3	10	5	0	
Beans	15	80	1	10	3	2	
Cucurbits	10	80	3	10	4	1	
Milk	40	55	6	20	10	2	
Eggs	50	70	6	20	5	2	
Poultry & Duck	40	70	6	20	5	2	
Sheep & Goat	20	55	6	35	7	1	
Cattle & Buffalo	25	55	6	20	10	2	
Marine	10	60	5	15	4	0	
Fresh	80	60	3	30	6	0	
Brakish	70	60	8	40	7	0	
Riverine	18	60	4	15	4	0	
Timber	10	60	3	20	5	0	Yes
Bamboo	10	70	2	20	10	0	

Appendix Table 2. Summary of Key Economic Assumptions

Commodity	Supply Elast	Dem-and Elast	Demand Shift Per Year	Initial Price Taka/MT	Initial Quantity 000 MT	Market Situation
Boro + T Aus	0.7	0.2		7364	5503	S. Open
B. Aus	0.11	0.2		7364	2140	S. Open
B. Aman	0.13	0.2		8484	1070	S. Open

Appendix Table 2. Continued.

T. Aman	0.13	0.2		8484	6573	S. Open
Wheat	0.2	0 7		4990	1066	S. Open
Barley	0.2	0.7		(3500)a.	12	S. Open
Maize	0.2	0.7		3984	3	S. Open
Millet	0.1	0.2	0.025	(2900)	42	Closed
Lentil	0.7	0.2		11229	156	S. Open
Gram	0.7	0.2		9936	78	S. Open
Blackgram	0.7	0.2		10340	47	S. Open
Mungbean	0·7	0.2		11917	33	S. Open
Mustard & Rape	0.3	0.5		11054	237	S. Open
Sesame	0.3	0.7	0.025	8480	51	Closed
Groundnut	0.3	0.7	0.025	9329	38	Closed
Coconut	0.1	0.3		4174	84	S. Open
Cotton	0.5	0.5		15045	29	S. Open
Jute	0,5	0.5		5273	1216	S. Open
Tea	0.1	0.4		33557	41	S. Open with exp subs
Tobacco	0.7	0.1		13455	43	S. Open
Betelnut	0.1	0 1		35740	22	S. Open
Betelleaves	0.2	0.1		12600	63	S. Open
Potato	0.3	0.5	0.025	3049	1141	Closed
Sweet Potato	0.3	1	0.025	1835	573	Closed
Aroids	0.3	0.2	0.025	1237	65	Closed
Chili	0.12	0.6		23837	44	S. Open
Onion	0.1	0.4		5602	136	S. Open
Garlic	0.1	0.4		21242	38	S. Open
Turmeric	0.1	0.4		19334	34	S. Open
Ginger	0.1	0.4		16703	40	S. Open
Sugarcane	0.1	0.1		670	6914	S. Open
Banana	0.4	0.3		6643	643	S. Open
Mango	0,7	0,3		8318	158	S. Open
Jackfruit	0.1	0.3	0.01	1920	239	Closed
Pineapple	0.7	0.3		5244	135	S. Open
Citrus	0.1	0.3		26125	14	S. Open

Appendix Table 2. Continued

Melon	0.7	0.3		3317	120	S. Open
Papaya	.7	0,3		5841	29	S. Open
Brinjal	0.13	0.2	0.025	3547	164	Closed
Tomato	0.1	0.2	0.025	3646	75	Closed
Radish	0.1	0.2	0.025	1815	143	Closed
Cauli & Cab	0.1	0.2	0.025	3091	121	Closed
Beans	0.1	0 2	0.025	3741	31	Closed
Cucurbits	0.1	0.2	0.025	3693	213	Closed
Milk	0.2	0.4		9993	690	S. Open
Eggs	0.4	0.2	0.025	1.8b.	1564215c.	Closed
Poultry & Duck	0.2	0.5	0.025	47179	65	Closed
Sheep & Goat	0.2	0 3	0.025	54148	50	Closed
Cattle & Buffalo	0.2	0.4		37748	283	S. Open
Marine Fish	0.7	0.5		(38000)	222	S. Open
Fresh Water Fish	0.7	0.5		(44000)	603	S. Open
Brakish Fish	0.7	0.5		(44000)	126	S. Open
Riverine Fish	0.7	0.5		(42000)	98	S. Open
Timber	0. 7	0.4		729	16281 (CFT)	S. Open
Bamboo	0.7	0.4		47	84201 (CFT)	S. Open

a. Numbers in Parentheses are estimates as no Pub, data are available
b. Price per Piece
c. 000 Pieces