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THE IMPACT OF PRIVATIZATION AND DEREGULATION ON NEW TECHNOLOGY DIFFUSION AND AGRICULTURAL GROWTH PERFORMANCE IN BANGLADESH - A MACRO VIEW

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ABSTRACT

Privatization and deregulation policies in modern agricultural input markets have influenced the rapid diffusion of new technologies in Bangladesh. During the privatization period, total rice area declined, while total rice production increased, signifying a remarkable achievement in improving land productivity. Rapid growth in the use of irrigation along with other technologies contributed to the significant increase in land productivity. Even the land-labor ratio decreased in the privatization period contributing significantly to an increase in total output and labor productivity. The present study concludes that privatization and deregulation policies enhanced effective growth of agricultural development in Bangladesh.

1. INTRODUCTION

Bangladesh has a population of about 120 million which is growing at the rate of about 2% per annum, adding 2 million people every year. Two-thirds of per capita income is spent on food and expenditure share of rice alone is about 40%. Further, demand for foodgrains is still increasing at around 3% per year (Hossain, 1990). On the other hand, cultivated land has decreased from 8.25 to 7.65 million hectares since the early 1970s to 1993. Rapid growth of population and urbanization were the main reasons for decreasing cultivated land area in Bangladesh (BBS, 1995). Thus, without technological progress there is no alternative way of maintaining food-population balance in Bangladesh.

To meet the growing need for foodgrains, the Bangladesh Agricultural Development Corporation (BADC) was established in 1960s. The main functions of BADC were to procure modern agricultural inputs (i.e. HYV seeds, fertilizers and irrigation equipment) and distribute these to the farmers at a highly subsidized price. Although these technologies have been in use in Bangladesh for more than three decades, improvement in agricultural output has been far below that of other less-developed countries. The subsidized input costs of the BADC were mostly borne by the foreign donor agencies. In the 1970s, diffusion of these technologies was slow. For example, the land area under irrigation was less than 17% of the net sown area, and the area under HYV was below 20%. Fertilizers used amounted to less than 50 kg of Nitrogen nutrients per hectare of cultivated land. Under such condition, the donor agencies advised to gradually reduce subsidy on inputs and to encourage privatization of the input markets in order

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to reduce development expenditures as well as to improve the resource use efficiency. The Government of Bangladesh (GOB) also faced budgetary constraints for subsidizing inputs at a very high level. Consequently, a series of privatization and deregulation policies were implemented in the agricultural input market beginning from 1980s (Table 1), which therefore became a significant decade in the history of agricultural development in Bangladesh. In the irrigation market, the system for distributing irrigation equipment was transferred from the government to the private sector. From the early eighties, the Deep Tube wells (DTWs) and Low Lift Pumps (LLPs) which were under rental system as well as the new ones were sold to the farmers' cooperatives (KSS) and private individuals at subsidized price. The subsidies were gradually decreased. The import duties on small diesel engines were also gradually decreased and finally removed. The standardization policies on small diesel engines were removed as well. The installation restrictions on tubewells were abolished (David, 1990). In the fertilizer and seed markets, the distribution systems were transferred from the BADC to private traders, and the subsidy on fertilizer decreased gradually.

Table 1. Step-by-Step liberalization of agricultural input markets in Bangladesh

Policy changes	Period	Remarks
A. HYV seed markets		
1. Except rice and wheat all seed import liberalized	1990	Modest response
B. Irrigation Markets		
1. BADC sold LLPs to farmers	1980-82	Good response from farmers
2. BADC sold all tubewells to farmers and cooperatives	1983-85	Good response from farmers
3. Restriction of import of engines and pumps withdrawn	1988	Drastic fall in prices of engines
4. Standardization restrictions withdrawn	1988	Drastic fall in prices of
5. Import duties removed	1988	Drastic fall in prices of engines
C. Fertilizer Markets		
I. BADC withdraw the primary distribution points from	1978-83	Vigorous response from traders
2. Licensing requirements was abolished	1982-83	
3. Deregulation of fertilizer price	1982-84	Real competition started
4. Allowed private traders direct purchase from factory gates	1989	Vigorous response from traders
5. Free import from world marker	1992	Good response

Source: Ahmed, R. (1995)

Various studies have shown an increase in rates of technology diffusion after the privatization and deregulation of the input markets and this growth in diffusion has been seen

to influence land productivity, labor productivity and total output growth. Rosegrant and Svendsen (1992) showed that the reduction of subsidies on fertilizer and other agricultural inputs has contributed to reduced growth in Asia since the early 1980s, although rice yield growth has increased steadily in India and Bangladesh from the 1970s through the 1980s. These recent policy and factor-product price changes have induced the diffusion of new technologies which contributing to further productivity growth. Ahmed (1995) found that the liberalization *of* modern agricultural input markets in Bangladesh contributed significantly to the increase in rice production in Bangladesh. He concluded that without market reforms, Bangladesh would revert to its former cycle *of* regular food crises and high rice prices. Hossain (1988) found that crop production growth increased from 2.5% in 1950-71 to 2.9% in 1971-85 and cereal growth increased from 2.6% to 3.4% at the same period. Alauddin and Tisdel (1993) found that green revolution technology increased the productivity *of* already cultivated land through multiple cropping. The productivity increase did not result from the extension of cultivated land or from higher yields from single cropping. Palmer-Jones (1992) observed that the growth of grain production since the 1960s reflects the gradual spread of HYVs, ground water irrigation, and increased use of chemical fertilizers. According to that study, the greatest growth has come from HYV *boro* rice. Most of the above studies focused mainly on agricultural growth performances with little evidence on the process and the status *of* the diffusion *of* new technologies (Rosegrant and Svendsen, 1992; Alauddin and Tisdel, 1993; Palmer-Jones, 1992; and Boyce, 1985). Moreover, the data used in the studies summarized above covered the period *of* mid-1980s. Some of the studies showed the growth rates at two endpoints of time (Hossain, 1988 and Boyce, 1985), while others focused on technological periods (Boyce, 1985) and took a political point *of* view (Hossain, 1988) or focused on both political and technological considerations (Alauddin and Tisdel, 1993). The latest policy changes, therefore, were not reflected in those studies, and their general conclusions could not be easily applied to the actual growth path of agricultural development since the policy changes were implemented.

Keeping in mind the findings of these earlier studies, the present study attempts at examining the process and status of the diffusion of new technologies and their impact on agricultural production from 1972 to 1993 in Bangladesh. The hypothesis is that the privatization of irrigation and other input markets has rapidly increased the diffusion of new agricultural technologies in Bangladesh. Irrigation along with other technologies has accounted for the rapid growth in land productivity of Bangladesh agriculture. As might be expected, the increase in land productivity has significantly contributed to the growth of total output and labor productivity during the privatization period. To verify the hypothesis, time series data covering the period from 1972 to 1993 have been used from different published and unpublished sources.

2. MODEL FOR ESTIMATING GROWTH RATES

Two aspects of the analytical framework warrant for discussion: (1) choice of sub-period, and (2) functional form. The choice of appropriate sub–period is decided by a prior consideration such as known turning points in the history of time series. The turning points result from innovations, political changes, and natural factors like a severe drought or flood. Boyce (1985) has divided the period of 1949–80 into two sub–periods of equal length considering the shift from the primacy of traditional technologies to new agricultural technologies in Bangladesh to have occurred around 1964–65. Hossain (1988) divided the 1949–84 period into three sub–periods: (i) 1949–58; (ii) 1959-71; and (iii) 1972–84. Hossain's choice seems to have been based more on political than technological consideration. In the present study, sub-periods are demarcated in a new way, on the basis of extent of privatization of agricultural input markets. The entire period 1972–93 can be broadly divided into two sub-periods: 1972–83 and 1983–93. The government-supported agricultural input market characterizes the first sub-period, which is the pre–privatization stage, and the second is characterized by the stage of privatization of agricultural technologies.

The choice of functional form mainly depends on the objectives of the study. In the present study, annual growth rates have been estimated by fitting the followed trend function;

$$lnY = a_o + a_1 D + b_o T + b_1 DT + u,$$

The trend function is used to determine the growth rates for other variables in the following sections. To analyze whether the growth rates of different variables have accelerated since 1983–93, the trend equation has been fitted for the entire period involving a dummy variable. In the above model, *ln* is the natural logarithm of the variables, *Y* is the variable for which the rate of growth is estimated. *D* is the dummy, taking value 1 for 1983–93 and 0 otherwise, and *T* is the time. The rate of growth for 1972–83 is given by b_o and that for 1983–93 is given by $(b_o + b_1)$. The value of b_1 is expected to be positive if there has been an acceleration of growth during the 1983–93. The coefficient of the dummy variable, a_1, will show whether any adjustment has been done since 1983.

3. PROCESS AND DIFFUSION OF NEW TECHNOLOGY

(a) Diffusion of High Yielding Variety (HYV) Seeds

In the late 1960s, HYV seeds for rice were imported to support the Accelerated Food Production Program sponsored by the Ford Foundation (Dalrymple, 1986). Thus during the 1970s, large quantities of HYV seeds were imported from the International Rice Research Institute (IRRI) in the Philippines and from India. In the year 1970, the Bangladesh Rice Research Institute (BRRI) was established to develop varieties better suited to local growing conditions. By 1994, BRRI had developed 25 short–duration HYVs (IRRI, 1994), while

several other HYV seeds were available from IRRI and Indian sources. The HYVs have higher vield rates and are superior to traditional varieties in disease resistance and grain quality. BADC has many seed multiplication farms throughout the country to produce qualitative seeds by the contract growers. BADC procured those seeds and supplied these to the farmers at subsidized prices after the approval of Seed Certification Board. BADC also imported various seeds through the private importers, and aside from rice and wheat, all seed imports were liberalized in 1990 (Ahmed, 1995).

In Bangladesh, HYV for seeds rice were first introduced in 1967. The use of HYVs for rice production was negligible until 1978 when it accounted for only 13% of the total rice area (Figure 1). By the end of 1983 the expansion of HYV seed covered one fourth of the total rice area. Expansion of area under HYV seeds was not fast at the beginning, however rapid progress was observed after 1983. By 1993, HYV seeds covered about half of the ricecultivated area, which is mostly *boro* rice.

(b) Development of Irrigation Facilities

The spread of HYVs and fertilizer use has largely followed the spread of irrigation. It is therefore the irrigation that has been termed the leading input (IRRI, 1995). In early 1960, the GOB approach to the expansion of irrigation facilities was through large-scale projects carried out by Bangladesh Water Development Board (BWDB). The areas irrigated by such projects made up a total of less than 10% of the total irrigated area, and were exceedingly costly because both the capital and current costs were borne by the government.

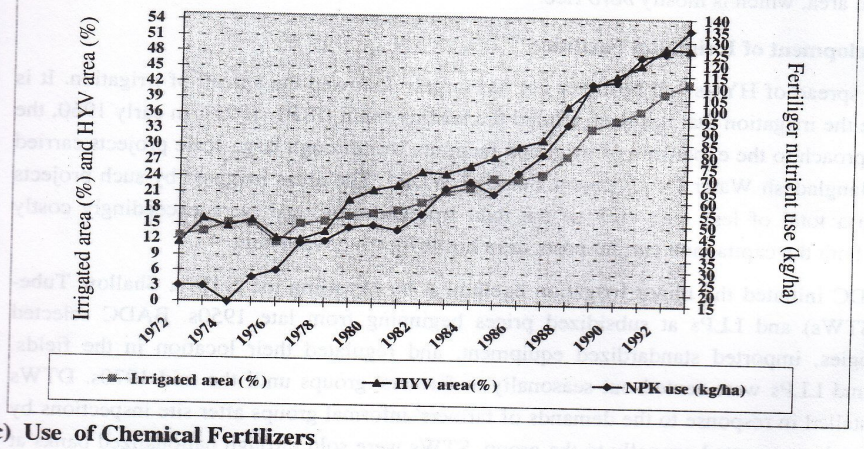
BADC initiated the minor irrigation equipment by installing the DTWs, Shallow Tubewells (STWs) and LLPs at subsidized prices beginning from late 1950s. BADC selected technologies, imported standardized equipment, and regulated their location in the fields. DTWs and LLPs were rented out seasonally to farmers' groups until the mid 1970s. DTWs were installed in response to the demands of farmers' informal groups after site inspections by BADC, and were rented annually to the group. STWs were sold through nationalized banks at subsidized credit beginning in 1974-75, and their installation was subject to controls through site sanction by BADC. BADC installed the tubewells and provided maintenance services at no charges while the farmers' group had to bear all costs including the wage of pump operators. The sale of STWs by the subsidized credit program under BADC continued until 1978-79.

Gradually the government expenditure on irrigation has declined as lending and assistance from donor agencies decreased. The subsidies decreased gradually, and privatization and deregulation policies were introduced in developing irrigation facilities during the period from 1980-88 (Table 1), the period when the system of distribution of irrigation equipment was shifted from government to the private sector. DTWs were sold to *KSS* and private individuals at a subsidized price. Import duties on small diesel engines were removed and the

standardization of engine and restrictions on tubewell installation were abolished (David, 1990). The liberalization of imports of small diesel engine resulted in drastic decrease in STW price (Ahmed, 1995) and number of STWs in operation increased rapidly.

Until 1987, the irrigated area was about one-fourth of the cultivated area but by 1993 the percentage increased upto 43% (Figure 1) and tubewell irrigation (DTW and STW) accounted for 70% of the total irrigated area. It was found that irrigation in Bangladesh was rice-based. Rice occupied more than 83% of the total irrigated area and again the share of *boro* rice alone was 71% (BBS, 1995).

Figure 1. Diffusion of HYV (% of total cultivated area), irrigation (% of total cultivated land) and use of Chemical fertilizrers (nutrient kg per ha) over 1972-93 in Bangladesh



(c) Use of Chemical Fertilizers

Before privatization, BADC had procured and distributed chemical fertilizers to farmers at highly subsidize prices. In 1968–69, the average amount of the subsidy was about 58% of the cost of N (nitrogen) and P (phosphate), and 67% of the cost of K (potash) (Hossain, 1995). With rapidly increasing sales, the government reduced the subsidy to 25% for N and P in 1983–84. Now, the rate of subsidies on all types of fertilizer is very low. In 1978, the distribution of fertilizer through dealers and *KSS* was abolished. The requiring of licenses was also abolished, and deregulation began from 1982–84 (Table 1). Under the changed systems, private traders could buy fertilizer from the factory gates as recommended by the BADC at government fixed price. The traders then sold it to farmers at market determined prices (Ahmed, 1995). Until 1983, BADC distributed fertilizer to primary sale centers and kept control over procurement until 1989. By 1992, the fertilizer market was fully liberalized and private traders were allowed to import from the world market.

In 1972, fertilizer use was about 23 kg of nutrient elements per hectare of cultivated land, but by 1983 this rate had increased to about 67 kg (Figure 1). Fertilizer consumption increased very quickly until 1989 when the use of fertilizer reached about 112 kg of nutrient elements per hectare of cultivated land. The rate of diffusion of fertilizer was then slowed down and its use reached to 136 kg of nutrients per hectare of cultivated land by 1993. It may be mentioned that the urea fertilizers are domestically produced while all of the potassium and some of the phosphorus fertilizers are imported (BBS, 1995).

4. COMPLEMENTARITY AND GROWTH RATE OF NEW TECHNOLOGIES

The analysis in the previous section showed a high degree of complementarity among irrigation, fertilizer use and diffusion of HYV seed. Irrigation was the leading input in the sense that adoptions of HYV seeds and application of fertilizers followed the development of irrigation facilities. Figure 1 shows that irrigated area rapidly increased after mid-1980s and the use of fertilizers and area cultivated under HYV seed also increased rapidly at the same time. The development and use of modern irrigation require prior capital investment and institutional arrangements that require the coordination of actions among many cultivators (Hossain, 1988). The adoption of HYV seeds and the application of chemical fertilizers, however, have resulted from decisions undertaken by individual cultivators. As a result, the rate of adoption of HYV seeds and fertilizers were found to be higher than the rate of expansion of irrigated area. The high degree of complementarity among seed, fertilizer, and water technologies suggests that the development of irrigation represent the key factor in the diffusion of modern technologies in Bangladesh.

The irrigated area grew only at 1.92% over the 1972-83 period, but during the period from 1983-93 it grew at the rate of 2.82%. Further, the growth of fertilizer consumption was about 5% from 1972 to 1983 while it was 3.35% during the period of 1983-93. Again, the area under cultivation of HYV seed grew at a rate of 3.22% from 1972 to 1983 and during the period from 1984 to 1993 it was 3.27% (Table 2). The coefficients of growth rates for irrigation, fertilizer and HYV seeds were found to be statistically significant. The analysis

Table 2. Annual growth rates (%) of HYV area, irrigated land and fertilizer consumption over 1972-93 in Bangladesh

Variables	1972-1983	1983-1993	Adjusted RZ
HYV area	3.22 (6.79)	3.27 (2.60)	0.94
Total irrigated area	1.92 (6.96)	2.82 (3.86)	0.97
Fertilizer consumption	5.11 (10.31)	3.35 (2.55)	0.95

Notes: Figure in the parentheses indicates t-values and all the values are significant at sy. Level.

showed that compared to pre-privatization period, the growth of diffusion rates for modern inputs was found to be higher in the privatization period except for the consumption of chemical fertilizers. The rate of growth of fertilizer consumption may have diminished, however, because of unfavorable factor prices.

5. RESPONSE OF FACTOR-PRODUCT PRICES IN DIFFUSION OF NEW TECHNOLOGIES

Here we examine, whether the factor and product prices have accelerated or decelerated the diffusion of new technologies. It was expected that the fertilizer price relative to rice price (i. e., the real fertilizer price) would influence the use of fertilizers. Similarly, compared to rice price the diesel price (taken as a proxy of irrigation price because cost of diesel represents about 65–70% of the total irrigation cost) affects the expansion of irrigation in direct proportion. The level of rice prices (i.e., the real rice price) in relation to other crop (i.e. mustard, oilseeds) influence the use of HYV in rice production. The availability of short–term crop loan as deflated by Consumer Price Index (i.e., the real short–term crop loans) also influence the use of chemical fertilizers. The relative factor and product prices are shown in Figure 2 and their growth rates are shown in Table 3. Figure 2 shows that real short–term crop loan rapidly increased during the pre–privatization period and sharply declined in the privatization period. The growth rate of real short–term crop loan was significantly positive in the pre–privatization period (5.41%) while it was significantly negative (–7.50%) in the privatization period (Table 3). This negative growth rate of crop loan may have influenced the decrease in the use of chemical fertilizers in the privatization period. The question arises, why

Table 3. Growth rates (%) of fertilizer price to rice price diesel price to rice price, short term crop loan to general price and rice price to other crop (mustard) over the period of 1972-93 in Bangladesh

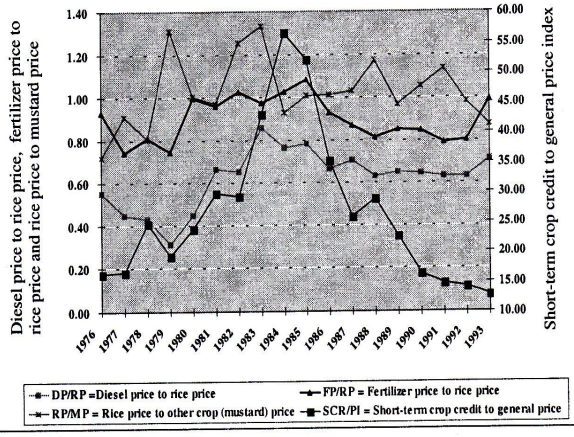
Relative factor and product price	1972-83		1983-93		Adjusted R^2
	Co-efficient	t-values	Co-efficient	t-values	
Fertilizer price to rice price (FR/RP)	1.42	2.01	-0.85	-0.54	0.46
Diesel price to rice price (DR/RP)	3.43	2.78	-0.71	-0.26	0.55
Short-term crop loan to general price (SCR/PI)	5.41	6.05	-7.50	-3.76	0.93
Rice price to other crop (mustard) (RP/MP)	3.20	3.92	0.09	0.05	0.52

Note: Data for some factors were not available from 1972, thus all growth rates during the period of 1972-83 indicate from 1976-83.

did the farmers not use more chemical fertilizers if the growth of real short-term crop loans in the pre–privatization period was so high? Perhaps this phenomenon can be explained by the growth of real fertilizer prices, which increased positively (1.42%) in the pre-privatization

period. Still, it should be noted that the growth rate of consumption of fertilizer was significant in the pre–privatization period. The real fertilizer price declined modestly in the privatization period (–0.85%), which bolstered the use of more chemical fertilizer (to an average 100 kg/ha). The growth of real rice price was significantly positive (3.20%) in the pre–privatization period which encouraged the adoption of HYV seeds and chemical fertilizers in this period.

Figure 2. Growth of fertilizer price to rice price, diesel price to rice price, short term crop loan to general price and rice price to other crop (mustard) price



The diminishing growth (0.09%) of real rice price (Table 3) also affected the modest growth rate of HYV seeds and fertilizer in the privatization period. The growth of the real diesel price increased (3.43%) during pre–privatization and decreased (–0.71%) during the privatization period (Table 3). This contributed to the growth of the irrigated area in the privatization period being higher than that of in the pre–privatization period. The prices of small diesel engines decreased by 11.80% (analysis from survey data) after privatization and deregulation, also influenced the expansion of irrigated area.

6. IMPACT ON AGRICULTURAL GROWTH

The impact of technological progress on the growth of crop production was found to be positive. In the present analysis, rice production was selected as a proxy for total crop production. Rice contributes about 73% of gross domestic production in the crop sector, and 85% of fertilizers and 83% of irrigated areas are devoted for rice production (Ahmed, 1995). Data were collected on the area cultivated with rice and on the production of rice for the period from 1972–93. The average rice yield was estimated by dividing the gross rice production by rice area.

The growth rates derived from the estimated trend function are presented in Table 4. The growth of rice output accelerated from 1.28% during the period of 1972–83 to 1.31% during 1983–93. This acceleration has taken place in spite of decrease in the total rice area in the privatization period. It is estimated that the growth of average rice yield has accelerated from 0.89% during the period of 1972 to 1983 to 1.39% during the period of 1983–93. The acceleration coefficients were found to be statistically significant. The average rice area increased significantly at a rate of 0.39% per year during the period of 1972–83, while it declined insignificantly at the rate of 0.09% during the period of 1983–93. Therefore, the total output of rice increased from increased rice yield. Thus, the impact of technological progress was reflected in the growth of land productivity.

Table 4. Land and labor productivity and land/labor ratio and their growth rates (%), and relative contribution of land productivity (%) to labor productivity and total output growth in Bangladesh

Variables	1972-1983 (Average)	1983-1993 (Average)	Adjusted R^2
Agricultural (rice) output per labor (Y/L) (ton/labor)	0.56	0.58	-
Agricultural (rice) output per ha of rice cultivated land (Y/A) (ton/ha)	1.25	1.58	-
Agricultural (rice) land area per labor (A/L) (ha/labor)	0.45	0.45	-
Growth rates:			
Total rice area (A)	0.39 (6.79)	-0.09 (-0.57)	0.79
Land productivity (Y/A)	0.89 (7.63)	1.39 (4.52)	0.96
Total rice output (Y)	1.28 (8.65)	1.31 (3.32)	0.95
Labor productivity (Y/L)	0.41 (2.96)	0.38 (1.02)	0.65
Relative contribution of land productivity to (%):			
Total output growth {G(Y/A)/G(Y)}	69	106	-
Labor productivity growth {G(Y/A)/G(Y/L)}	217	366	-

Note: Figure in the parentheses indicate t-values, and all the values are significant except the growth coefficient of total rice area and labor productivity over 1983-93.

The relative contribution of land productivity was measured using the following notations:

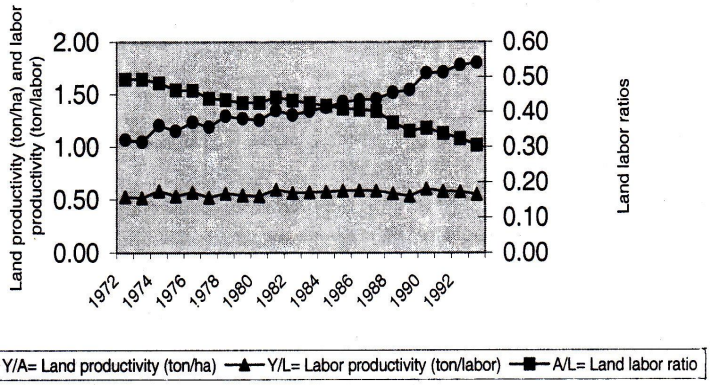
$$Y = A.\ (Y/A)$$

$$Y/L = (Y/A).\ (A/L)$$

Where, A = Total cultivated area, Y = Total rice output, L = Total agricultural labor force

Productivity of land (Y/A) and labor productivity (Y/L), and land–labor ratio (A/L) were estimated and presented in Figure 3. It was found that land–labor ratios decreased sharply in the privatization period while land productivity as well as labor productivity increased. Land–labor ratios were found to be inversely related to land productivity. Lower land productivity was compensated by the high land–labor ratios in the pre–privatization period (Figure 3).

Figure 3. Land and Labor Productivities and Land Labor Ratios over 1972-93 in Bangladesh



Similarly, unfavorable land-labor ratios were compensated by the higher land productivity in the privatization period, resulting in comparable labor productivity. The differences in the land–labor ratio and land productivity between the pre-privatization and privatization periods are reflected in the lower rate of diffusion of new technologies during pre-privatization. As a result, the relative contribution of land productivity to the total output growth was only 69% in the pre–privatization period while it was 106% during privatization period (Table 4). Similarly, the relative contribution of land productivity to labor productivity growth increased from 217% to 366% from pre-privatization to privatization period.

7. CONCLUDING REMARKS

Private investment in irrigation and deregulation of agricultural input markets during 1980s abruptly improved the diffusion of new technologies. The growth in the consumption of chemical fertilizers was found to be increased at a diminishing rate in the privatization period. The decrease in real short–term crop loan contributed to the reduction in the growth of fertilizer use, even though fertilizer use still increased in these years. Decrease in the real

prices of diesel and tube-wells significantly contributed to an increase in the expansion of irrigated area. The modest growth of HYV-cultivated areas was due to a decrease in the rice prices compared to other crop. The growth of the rice area declined in the privatization period, but total rice production significantly increased due to the remarkable increase in land productivity in the privatization period. Thus, the increase in land productivity in Bangladesh has resulted from technological progress, and there remains a vast potential for further diffusion of new technologies. The increase in land productivity contributed in turn to increases in total output and in labor productivity growth during the privatization period. The present study therefore finds that the privatization and deregulation policies induced the diffusion of new technologies and positively contributed to the agricultural development in Bangladesh.

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