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AGRICULTURAL GROWTH THROUGH CROP DIVERSIFICATION IN BANGLADESH

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FOREWORD

In early 1989, the International Food Policy Research Institute entered into a contract with the U.S. Agency for International Development (USAID), Dhaka (under contract No. 388-0027-C-00-9026-00), to conduct research on food policies and to extend technical assistance to the Ministry of Food, Government of Bangladesh. The Bangladesh Food Policy Project is the basis for a tripartite collaboration between IFPRI, the Government of Bangladesh, and USAID, Dhaka. This project consists of four subprojects and a large number of well-defined research topics. The subprojects together constitute a comprehensive approach for addressing the food policy problems in Bangladesh. They include the following studies: a price stabilization framework encompassing public and private marketing, evaluation of the effects of targeted distribution of foodgrains on consumption and nutrition, diversification of agriculture as a source of sustained growth of production, and capacity-building in food policy analysis.

This paper on agricultural growth through crop diversification is the principal output under the subproject on diversification of agriculture as a source of sustained growth in production. The research was conducted in collaboration with the Bangladesh Institute of Development Studies. The paper shows that there are quite a number of products other than rice that portend substantial diversification and agricultural growth. Exploitation of this potential is critical for future growth, since Bangladesh is approaching self-sufficiency in rice production and has a limited potential for export of that crop.

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Series Editor and Project Director
Bangladesh Food Policy Project

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1. AN OVERVIEW

This study is aimed at outlining the policies and issues of crop diversification that are likely to influence the growth and sustainability of agricultural production in Bangladesh. Crop agriculture currently accounts for more than one-fourth of the gross domestic product (GDP) at market prices and nearly 60 percent of the commodity production in the economy. The crop sector is dominated by rice, which alone now accounts for nearly 70 percent of the gross farm revenue from crop production. For the nearly two decades under review (1973-90), the growth in crop agriculture has been predominantly led by foodgrains, mostly rice. As the country now appears to be approaching self-sufficiency in rice, questions have been raised about the sustainability of rice-led agricultural growth (see, for example, World Bank 1991). The success in accelerating rice production may have thus brought new challenges and opportunities to make agriculture more efficient and more flexible. It is in this context that the issue of crop diversification needs to be addressed as part of the broader agricultural development strategy.

The prospects of agricultural growth through crop diversification raise a great many issues concerning agronomic sustainability, farm-level incentives, changing technologies, marketing efficiency, comparative advantage, and macrolevel supply-demand balances. There are even broader issues involving the income-distributional and nutritional linkages of crop diversification and the longer-run role of crop agriculture in an economy undergoing a process of structural change. The scope of this study has been modestly defined in order to focus on only a few of these issues. In particular, the emphasis has been on a source-of-growth analysis regarding the crop sector's performance (Chapter 2), leading to an assessment of agricultural supply response behavior (Chapter 3) and an evaluation of the structure of farmer incentives in relation to comparative advantage in crop agriculture (Chapters 4 and 5). The study, however, falls short of integrating the findings into full-fledged growth scenarios for crop agriculture, delineating the role of crop diversification.

The deficiencies of official crop statistics, particularly for noncereal crops, pose a serious problem for undertaking any economy-wide analysis of the prospects for crop diversification. This study has used a comprehensive data base that, in terms of disaggregation of crops, is similar to that used in the official national income accounts, but revisions have been made regarding data on certain crops to make these consistent over time. The estimated trend growth rates for periods since the early 1970s suggest that growth in crop production has barely kept pace with population growth (the latter being estimated at about 2.3 percent annually for the 1970s and about 2 percent for the 1980s).

Compared with the study estimates, considerably higher rates of growth of the crop sector are implied by the official national income series, which probably are not really consistent over time for the crop sector. In particular, the official statistics do not appear to adequately capture the fact that the growth in foodgrain production has been to some extent at the expense of noncereal crops.

The source-of-growth analysis shows that virtually the entire growth in gross farm revenue (at constant prices) has been due to increased production of foodgrains alone. For the crop sector as a whole, the contribution of area expansion to growth has declined over time, so that almost the entire production growth in the 1980s has come from the increase in revenue yield per hectare of gross cropped land. For noncereal crops taken together, it is this increase in productivity per hectare that has kept the total value of production from falling, since there has been a significant decline in area, particularly in the 1980s. It is, however, important to note that these productivity improvements appear to have resulted from reallocation of area in favor of higher-value crops rather than from any sustained yield improvements for individual crops or crop groups.

The area under noncereal crops taken together has continuously fallen since the late 1970s, mainly due to the expansion of modern irrigation, which strongly favors the cultivation of dry-season (boro), high-yielding variety (HYV) rice.[1] Most noncereal crops are grown predominantly on nonirrigated land, and with the notable exception of jute, compete for land in the dry season; these crops are therefore liable to be displaced with the expansion of irrigation.[2] Between the early and the late 1980s, the net addition to the dry-season cropped area was only about half of the additional coverage of irrigation, presumably because irrigation has been provided increasingly on land that is already under dry-season cultivation.

The cropping patterns in the country can be broadly classified into rainfed and irrigated patterns, which again vary according to the degree of seasonal flooding. Comparisons across land types show that, among all categories of land by flood-depth levels, the proportion of land allocated to noncereal crops is markedly lower under irrigated conditions than under rain-fed conditions. However, there is also a sharp contrast in the cropping patterns between modern and traditional irrigation, the latter being clearly more conducive to a diversified cropping pattern. Traditional irrigation on flood-free land in fact appears to strengthen the cultivation of high-value crops like potatoes, vegetables, and spices. It is generally believed that traditional irrigation, which requires very little investment in fixed capital, is already stretched to its limit. An important policy concern in this

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[1] HYV boro rice also displaces wet-season rice varieties, namely, local aus and broadcast aman, due to overlapping growing seasons.

[2] Among nonrice crops, only wheat, potatoes, and vegetables are grown equally on irrigated and nonirrigated land.

context is the potential scope for promoting "intermediate" irrigation technology, such as represented by hand tubewells and treadle pumps. These labor-intensive irrigation techniques are found to be particularly advantageous for small farmers and for growing crops like vegetables, potatoes, and spices.

There is an apparent paradox in that land under modern irrigation is almost exclusively devoted to rice cultivation even though the production of many high-value noncereal crops under irrigated conditions is potentially much more profitable. The answer may lie in a combination of technical and economic factors. On the one hand, there are very high price risks associated with the marketing of most of these crops. The average annual variability of harvest prices around the estimated trend is found to be as high as 15-25 percent for most fruits and vegetables including potatoes and 20-40 percent for spices, compared with only 5-6 percent for foodgrains. On the other hand, the existing irrigation and on-farm water management systems do not allow rice and nonrice crops to be planted in the same service units. Growing nonrice crops under modern irrigation would therefore often require the farmer to allocate all his land (or most of it) to these crops--hardly a preferable option to a risk-averse farmer. Traditional irrigation, being divisible, allows farmers to grow these high-value, but risky, crops on small parcels of land. The problem may be addressed in several ways, namely, by (1) reducing the price risks through improved marketing, (2) making the nonrice crops more profitable through technological improvements so as to compensate for high price risk, and (3) introducing water management systems that allow rice and nonrice crops to be grown within the same service units.

The currently practiced cropping patterns evidently offer little scope for crop diversification through expansion of modern irrigation. It is not surprising therefore that the prospects for crop diversification are often sought in more intensive cultivation of nonirrigated land.[3] But there may not remain much scope for this, as would appear from the recent trends in cropping intensities, particularly for dry-season nonirrigated crops. There is, however, considerable scope for increasing the yields of noncereal crops through better farm practices and varietal improvements even under nonirrigated or semi-irrigated conditions (Ministry of Agriculture 1989b). Such yield improvements, rather than more-intensive cultivation of land, perhaps offer better growth prospects for these crops. The real prospects for crop diversification, however, would still depend on how far technological innovations could make noncereal crops competitive under conditions of modern irrigation.

Research and extension activities in the past were mainly concentrated on HYV rice to the neglect of most other crops. Among noncereal crops, the HYV technology is well established only in potato cultiva-

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[3] See, for example, the projections made for the National Water Plans in Master Plan Organisation 1991, vol. 2.

tion. It is only recently that HYVs with very high yield potentials have become available for some vegetables and fruits like tomatoes, beans, watermelons, and bananas. Improved technologies are also now available for pulses, mustard, jute, sugarcane, maize, sweet potatoes, and some country vegetables. However, the technical and socioeconomic constraints to the diffusion of improved technologies in the case of noncereal crops are still little understood. Much will depend on how far adaptive research and extension activities can be strengthened to identify and overcome these constraints. In particular, provision of credit and improved marketing facilities are likely to be important determining factors in the adoption of the new technologies, which are often highly resource-intensive.

The econometric estimates of supply response functions for various crops suggest that price incentives do matter in farmers' decision-making, but outward shifts in the supply curve arising from technical changes are likely to be more important in determining long-run changes in supply. In crop area allocation, farmers are found to respond much more strongly to yield improvements (or declines) than to price changes. This gives an added importance to policy measures that support technical improvements for high-value crops such as vegetables and spices. Such technological improvements would contribute to the growth of crop agriculture not only through increased yields but also through the induced shift of land toward these high-value crops. Greater specialization by farmers through the adoption of improved technologies for these crops would also probably lead to a more stable and price-responsive farm supply behavior.

The estimates of "economic" profitability of crops, as distinct from private profitability, can help in deriving meaningful policy conclusions on how to reorient farming systems toward socially profitable patterns. The profitability analysis undertaken for this study yields a number of conclusions that appear robust in spite of many conceptual and data limitations. An important aspect of the profitability estimates for the rice crops is the implied incentives for shifting from local to modern varieties, which remain the main source of growth in rice production. The economic gains from such a shift are found to be quite large in the import and nontraded situations, and in terms of private returns at the existing level of domestic rice price. However, if the export parity price is used, the economic gains from adoption of the HYVs are greatly reduced and may even be eliminated in some cases. Moving to a rice-export regime would generally imply a very substantial decline in the profitability of agricultural production (and in the returns from irrigation investments) as a whole, given the dominance of rice in crop agriculture. Judging from the profitability estimates of many nonrice crops, it would appear that the country has more profitable options compared with rice export at the prevailing world price of rice. This in turn raises the question of sustaining the profitability of nonrice crops as well in the face of market demand constraints. It also remains doubtful whether the implied decline in private profitability would allow rice production to grow rapidly enough so as to actually generate an exportable surplus.[4] This does not, however, rule out the possibility that the export of certain special varieties of rice (such as high-quality aromatic rice) can be highly profitable, in terms of both private and economic returns.

A striking feature of the profitability estimates is that a number of crops such as potatoes, vegetables, onions, and cotton show economic and private returns that can be significantly higher than those of HYV rice. While this suggests that there exists potential scope for reorienting the existing cropping patterns in a socially profitable way, the constraints to such a reorientation of the crop economy need to be addressed. Jute also has a competitive edge over local rice at the prevailing world price of jute. By contrast, wheat, sugarcane, and oilseeds show very low, even negative, economic returns, although in the case of sugarcane, private returns are quite high. Sugarcane production appears to generate negative economic returns even for making gur, which is an inferior substitute for imported refined sugar.

To assess the likely impact of technological improvements on comparative advantage, estimates of expected profitability are obtained on the basis of the production input coefficients envisaged under the improved production techniques. A number of crops such as potatoes, lentils, cotton, and jute show the potential of becoming even more competitive with rice in their respective growing seasons. The most spectacular gains in profitability can be seen to arise from the adoption of certain high-yielding varieties of vegetables. However, wheat and sugarcane do not appear promising in spite of technological improvements. But it is the case of mustard seed that is the most remarkable in that the economic profitability remains negative, even though a substantial increase in yield is envisaged. This has something to do with the low world price of oilseeds and the nature of the improved production technology that is currently available.

It is important to examine how far the structure of incentives created by trade policies is in conformity with the country's comparative advantage. Regarding rice, there has been some moderate decline in the domestic price of rice in real terms since the mid-1980s, and this has caused some concern among policymakers about the resulting effect on the profitability of rice production. However, these price movements may be interpreted as a reflection of a changing comparative advantage in Bangladesh agriculture as the country approaches self-sufficiency in rice (and as the domestic rice price moves downward while remaining within the band of the import and export parity prices). Wheat appears to be slightly protected, although there can be little justification for such protection on the basis of comparative advantage. However, the major anomaly in the incentive structure seems to be in sugarcane and oilseeds, which show no comparative advantage but enjoy high rates of protection. The estimates of expected profitability with technological

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[4] To allow rice exports to take place, the actual farmgate price of rice would have to decline by about 25-30 percent compared with the price used here in the present estimates of private profitability.

innovations suggest that, in the case of sugarcane and oilseeds, there is not even ground for applying the "infant industry" argument, if such an argument is at all relevant for crop production. The low economic profitability of sugarcane and oilseeds, as well as the prevailing high rates of protection for these crops, has arisen largely from the sharp declines in the international prices of sugar and oilseeds.

On the other hand, the trend decline in the real price of pulses in the world market was much smaller than that of other agricultural commodities. This, along with the fact that the country has become an importer of pulses, largely explains why this crop now appears to have a relatively high economic value. The price of potatoes has also declined relatively modestly in the world market, so that there is some potential for potato export to be economically profitable. Regarding vegetables, although domestic prices are found to be far too low compared with export prices, this cannot be blamed on the trade policies being pursued. This is rather a reflection of limited access to the world market and lack of infrastructural facilities for export. Nevertheless, the estimates of high economic profitability of vegetable export point to the need for government support to promote such export.

Another way of looking at the profitability estimates for nonrice crops is that the country does not seem to have comparative advantage in those items that currently compete with major imports, namely, wheat, sugar, oilseeds, and edible oils.[5] On the other hand, the crops that show high economic profitability, such as potato and vegetables, are currently produced either entirely for the domestic market, or have only limited access to the world market. While import substitution, by its very nature, does not encounter a market problem, the profitability of nontraded crops would depend on the growth of domestic demand in relation to output growth. (Another related aspect is that, while import liberalization of, say, sugar and edible oils would create pressure on the balance of payments, shifting to nontraded crops would not have a compensating favorable impact.) The domestic markets for noncereal crops, especially the high-value ones, are limited in size because of the generally low living standards in the country. This underscores the need for exploring the possibility of export of crops that have a potential comparative advantage.[6] In the past, however, the production of vegetables, potatoes, spices, and fruits did not grow rapidly enough even to satisfy the growth in domestic demand, not to speak of creating an exportable surplus. Efforts at export promotion therefore need to be part of an integrated strategy of technological improvements and development of marketing and processing facilities that could elicit better supply responses.

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[5] Cotton seems to be an exception, but it is still a very minor crop.

[6] The list of such crops may include many horticultural products and spices that have not been included in the present profitability exercises.

2. GROWTH PERFORMANCE IN CROP AGRICULTURE

Growth in crop agriculture, in the aggregate, can be primarily decomposed into two factors: expansion of the cropped land and improvements in productivity per unit of cropped land. The first factor, in the context of Bangladesh agriculture, mainly reflects changes in the cropping intensity of land, since there is little scope for expansion of net cultivated area. Productivity improvements, in turn, can be seen to result from increases in the physical yield rates of particular crops as well as from changes in the cropping pattern such as a shift of land from low-yielding (or low-value) crops and crop varieties to the high-yielding (or high-value) ones. Such a disaggregated analysis of growth, although based on only descriptive statistics and accounting relations, can help to identify where the sector's main problems and prospects lie, particularly in relation to growth through crop diversification.

PRODUCTION GROWTH

The Data Base

To analyze the pattern of growth in crop agriculture, a comprehensive data base has been used; in terms of disaggregation by crop, it is similar to that used by the Bangladesh Bureau of Statistics in the official estimates of agricultural production indexes and national income accounts. A problem arises, however, from the fact that the official crop statistics for 1983/84 onward have undergone major revisions in area and production of three crop groups, namely, pulses, oilseeds, and minor cereals. These revisions have been made in the light of findings from the 1983-84 *Census of Agriculture* and have involved upward adjustments of the previous area and production figures by 2 to 3 times in most cases.[7] These adjustment factors have been applied to the official data of the previous years to construct consistent time series covering the entire period under review. Given the extent of these adjustments, any estimates involving these time series have to be treated with caution.

There are serious shortcomings in the official data for other crops as well. The production of vegetables and spices in particular are likely to be grossly underestimated. The area under these two crop

[7] Both the revised and unrevised official data for these crops are available for three years from 1983/84 onward; for every year, the adjustment factor for each crop is the same at the national aggregate level. The official crop statistics are reported in the various publications of the Bangladesh Bureau of Statistics, for example, Yearbook of Agricultural Statistics and Monthly Statistical Bulletin (various issues).

groups as reported in the 1983-84 *Census of Agriculture* is almost twice as high as the official estimate for the same year (Norbye 1989; Rashid 1989). Most of the horticultural production on homestead land is likely to be missed by the official crop statistics. These data deficiencies pose a major problem in conducting any study on crop diversification and point to the need for improvement of the system of agricultural statistics.

SOURCES OF GROWTH

For a disaggregated analysis of production growth, the time series of gross value of production has been constructed by major crop groups at 1984/85 constant prices. For this, the same farmgate prices as those used in the national income accounts for the crop sector have been used here, but (to avoid the effect of annual price fluctuations) the estimated prices at their trend level for that year have been used instead of the actual 1984/85 prices.[8] Estimating the growth of production from these time series of gross value of production is, of course, equivalent to using the Laspeyres production index with the 1984/85 base (which is, incidentally, the base year for the new official national income series as well). These time series can also be used, together with crop area data, to estimate trends in crop yields in value terms (that is, gross farm revenue per hectare at constant prices). It may be noted that variations in productivity per hectare, so estimated for a crop group, will reflect not only changes in physical yields of the component crops but also changes in area allocation within that crop group. Tables 2.1 to 2.5 present some of the above estimates that may be relevant for a source-of-growth analysis.

The annual growth of production for the crop sector as a whole turns out to be 2.08 percent and 1.62 percent, respectively, for the two overlapping periods of 1973/74-1983/84 and 1979/80-1989/90 (Table 2.1). The statistical estimate of the trend growth for the later period presents some problems because of the adverse effect of severe floods in the two consecutive years of 1977/78 and 1978/79 and the sharp upturn in rice production in the postflood years. Dissociating the effect of floods (through the use of dummies for the two flood years) gives an estimated trend growth rate of 2.05 percent annually for the period of the 1980s. It would thus appear that the overall growth in crop agriculture has barely kept pace with population growth, which is estimated to have been 2.3 percent annually in the 1970s and about 2.0 percent in the 1980s.

There is a serious discrepancy between the above growth estimates for the crop sector and those obtained from the official national income series. The new national income series at 1984/85 constant prices is

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[8] Semilogarithmic trend lines have been fitted to price data for the period from 1975/76 to 1986/87. Farmgate prices are those prevailing in the primary markets during the harvesting seasons, net of homestead-to-market transport costs.

Table 2.1--Trend rates of growth of area and production of agricultural crops

Crop	1973/74-1983/84 Area	1973/74-1983/84 Production	1979/80-1989/90 Area	1979/80-1989/90 Production
		(percent/year)		
Foodgrains	1.20*	2.74*	0.13	2.33*
Paddy	0.72*	2.19*	0.05	2.42*
Wheat	18.33*	26.47*	1.77	0.19
Nonfoodgrains	-0.53	0.57*	-1.73*	-0.28
Jute	-0.85	1.20	-1.51	-0.44
Oilseeds	-0.20	0.66	-1.55*	-0.57
Pulses	0.15	-0.94	-2.84*	-1.82*
Spices	0.05	-0.65	-0.51	1.32*
Fruits	1.66	-0.08	1.30*	-0.04
Vegetables	2.24*	2.12*	2.85*	1.99*
Tubers	1.74*	2.93*	-0.39	-0.15
Sugarcane	1.35*	1.27*	1.85*	0.54
Tea	0.37	3.93*	0.71*	0.61
Minor cereals	-6.88*	-5.80*	-12.03*	-11.42*
All crops	0.78*	2.08*	-0.28	1.62*

Notes: For crop groups and "all crops," the growth of production is estimated from time series of gross value of production at 1984/85 farmgate prices. The prices used are at the estimated trend level for 1984/85. Paddy includes three seasonal crops in value terms. Tubers include potatoes and sweet potatoes. For oilseeds, pulses and minor cereals, consistent time series of area and production are derived by adjusting the official crop data as described in the text. See also Appendix 2, Table A2.2. Growth rates are estimated by fitting semilogarithmic trend lines.

* Estimated growth rate is statistically significant at the level of 5 percent or less.

available, in the published form, only for 1984/85 onward, but the unpublished series extends back to 1972/73 and is reported in World Bank 1992. The trend annual growth rate of value added in crop agriculture estimated from this series turns out to be 3.41 percent and 2.73 percent, respectively, for the above two periods considered (against estimates in this study of 2.08 and 1.62 percent for the gross value of production). This discrepancy cannot be explained merely by methodological differences or by the fact that the growth rate of production would presumably vary from that of value added. The year-to-year growth rates in the two series vary widely only for some particular years. For example, between 1980/81 and 1981/82, the official series shows a growth rate of above 7 percent, compared with a negative growth rate in our series (Appendix 2, Table A2.1). This was a time when there was in fact a decline in the production of major crops (rice, wheat, and jute) in physical terms, which renders the official series quite incredible. The official series is probably not really consistent over time; the inconsistencies may have arisen from many sources, such as the upward revision of production data for pulses, oilseeds, and minor cereals and

Table 2.2--Crop yields in taka per hectare and gross value share of crops at 1984/85 farmgate prices

Crop	Gross Value of Output per Hectare[a]			Share in Crop Sector's Gross Value of Output[b]		
	1973/74-1977/78	1979/80-1983/84	1985/86-1989/90	1973/74-1977/78	1979/80-1983/84	1985/86-1989/90
	(Tk 1,000)			(percent)		
Foodgrains	7.7	8.4	9.6	68.4	71.2	74.0
Paddy	7.8	8.5	9.7	67.6	67.9	71.0
Wheat	5.6	8.2	7.3	0.8	3.3	3.0
Nonfoodgrains	10.4	11.1	12.0	31.6	28.8	26.0
Jute	6.2	7.0	7.6	3.6	3.5	3.6
Oilseeds	5.7	5.9	6.3	3.2	2.9	2.5
Pulses	4.7	4.4	4.7	3.6	2.9	2.4
Spices	19.4	18.6	20.9	2.6	2.1	2.1
Fruits	52.5	47.4	44.1	6.3	5.5	5.0
Vegetables	15.8	15.7	14.8	1.6	1.6	1.6
Tubers	18.3	19.4	19.7	2.5	2.6	2.3
Sugarcane	23.6	23.5	21.7	3.0	2.8	2.6
Tea	37.0	44.6	44.2	1.4	1.5	1.4
Minor cereals	2.6	2.8	2.8	0.9	0.6	0.3
All crops	8.4	9.1	10.1	100.0	100.0	100.0

Note: For crop groups and "all crops," the growth of production is estimated from time series of gross value of production at 1984/85 farmgate prices. The prices used are at the estimated trend level for 1984/85. Paddy includes three seasonal crops in value terms. Tubers include potatoes and sweet potatoes. For oilseeds, pulses and minor cereals, consistent time series of area and production are derived by adjusting the official crop data as described in the text. See also Appendix 2, Table A2.2.

[a] Five-year average.

[b] Estimated from five-year averages of gross value of output; does not add up to 100 because some crops are excluded.

the inclusion of by-products in the estimation of value added from the early 1980s onward.[9]

A remarkable finding of the present source-of-growth exercise is that virtually the entire growth in gross farm revenue is due to growth in foodgrain production alone (Figure 2.1). Foodgrain production has grown clearly ahead of population all along, although there appears to be some deceleration in growth in the 1980s. This later phenomenon is due to the stagnation in wheat production, since the growth rate of rice production in fact accelerated in the 1980s (which becomes more evident if the time series is extended up to 1980/81; see Table 2.3). Among nonfoodgrain crops and crop groups, only vegetable production has steadily grown at nearly the rate of population growth (Table 2.1).

[9] The old national income series at 1972/73 constant prices, which has recently been discontinued, also probably suffers from similar inconsistencies, since the growth rates estimated from this series are also equally high (see World Bank 1990a, table 1.4).

Table 2.3--Trend rates of growth of area, production, and yield of rice crops

Crop[a]	1973/74-1983/84 Area	Production	Yield	1979/80-1990/91 Area	Production	Yield
			(percent/year)			
Local aus	-1.39*	0.58	-0.82	-3.42*	-1.24	2.18*
MV aus	9.23*	6.18*	-3.05*	-1.33	-3.06*	-1.73*
All aus	-0.31	0.79	1.10*	-3.22*	-2.06*	1.06*
Local T aman	0.64	1.51	0.87	-1.62*	-.05	1.57*
MV aman	7.39*	5.24*	-2.14*	6.27*	7.03*	0.75*
B aman	-1.78*	-0.21	1.57*	-5.06*	-4.24*	0.83
All aman	0.79*	1.74*	0.95*	-0.51*	1.80*	2.30*
Local boro	-2.90*	-0.65	2.24	-3.63*	-4.66*	-1.03
MV boro	6.10*	6.79*	0.69	10.89*	10.44*	-0.45
All boro	3.02*	5.12*	2.10*	7.72*	8.52*	0.78*
All MV rice	6.84*	5.78*	-1.06*	7.23*	7.48*	0.25
All rice	0.72*	2.20*	1.49*	0.06	2.63*	2.56*

Notes: Growth rates are estimated by fitting semilogarithmic trend lines. For all varieties of aman except MV aman, growth rates for the second period are estimated by using dummy for the flood year of 1988/89.

[a] MV = modern variety, including both high-yielding varieties and Pajam; T = transplant; B = broadcast.

* Estimated growth rate is statistically significant at the level of 5 percent or less.

Table 2.4--Trends in yield rates and share of rice crops in total rice production

Crop[a]	Yield[b] 1973/74-1977/78	1979/80-1983/84	1985/86-1989/90	Production Share[c] 1973/74-1977/78	1979/80-1983/84	1985/86-1989/90
	(metric tons/hectare)			(percent)		
Local aus	0.79	0.82	0.92	19.0	15.7	13.0
MV aus	2.50	2.09	1.79	6.1	7.1	5.2
B aman	0.93	0.99	0.99	13.4	11.2	7.2
Local T aman	1.18	1.20	1.32	33.2	30.2	26.4
MV aman	2.25	1.95	2.05	10.5	13.9	17.4
(HYV aman)	(2.28)	(2.09)	(2.13)	(9.5)	(8.1)	(12.7)
(Pajam aman)[d]	(2.20)	(1.78)	(1.87)	(1.0)	(4.2)	(2.6)
Local boro	1.30	1.49	1.35	4.8	4.2	2.6
HYV boro	2.57	2.71	2.62	13.0	17.8	28.1

[a] MV = modern variety, including both high-yielding varieties (HYVs) and Pajam; B = broadcast; T = transplant.

[b] Five-year average of yield rates in clean rice equivalent.

[c] Estimated from five-year averages of production in physical terms.

[d] A locally improved variety.

Table 2.5--Trend rates of growth of area, production, and yield of nonrice crops

Crop	1973/74-1983/84 Area	1973/74-1983/84 Production	1973/74-1983/84 Yield	1979/80-1990/91 Area	1979/80-1990/91 Production	1979/80-1990/91 Yield
			(percent/year)			
Wheat	18.33*	26.47*	8.14*	1.77	0.19	-1.58
Jute	-0.85	1.20	2.05*	-1.51	-0.44	1.07
Sugarcane	1.35*	1.27*	-0.09	1.85*	0.54	-1.30
Potato	2.91*	4.18*	1.27*	1.47*	1.23	-0.23
Sweet Potato	0.04	0.00	-0.03	-3.74*	-4.12*	-0.38
Tea	0.37	3.93*	3.56*	0.71*	0.61	-0.09
Tobacco	0.60	1.03	0.60	-1.05	-1.90	-0.86*
Oilseeds						
Mustard	0.11	1.70	1.59*	-1.62*	-0.98	0.64
Til[a]	-2.70*	-2.84*	-0.15	-3.52*	-2.74*	0.78*
Linseeds	1.19*	1.68*	0.49	-0.66	1.82*	2.47*
Groundnut	0.26	-2.84*	-3.09*	0.15	0.98	0.83
Coconut	2.00*	3.50*	1.50*	1.29*	1.26*	-0.03
Pulses						
Masur[b]	1.67	0.53	-1.14	-2.90*	-0.35	2.55*
Gram	-0.41	-0.32	0.09	-2.37*	-2.29*	0.08
Mung[c]	2.38	1.10	-1.28	-0.55	-0.68	-0.13
Mashkalai[d]	-2.92*	-4.28*	-1.34*	-4.95*	-4.85*	0.24
Khesari	-0.80	-1.03	-1.84*	-2.88*	-2.47*	0.41
Fruits						
Banana	1.55*	2.02*	0.47*	-0.33	-0.08	0.41
Mango	1.01*	-6.01*	-7.03*	1.12*	-2.45	-3.57*
Melon	3.20*	1.60*	-1.60*	3.00*	0.78	-2.22*
Pineapple	1.09	-0.33	-1.41	1.06*	0.50	-0.56
Vegetables						
Tomato	2.67*	2.65*	-0.01	2.85*	2.93*	0.09
Radish	3.92*	4.45*	0.53	4.01*	5.05*	1.04*
Brinjal	0.62*	-0.08	-0.71	-0.03	-2.16*	-0.92
Spices						
Chilli	0.17	-0.79	-0.96	-1.61*	0.63	2.24*
Onion	0.55	-1.63	-2.18*	0.87*	1.62	0.76

Notes: Growth rates are estimated by fitting semilogarithmic trend lines. For pulses and oilseeds, consistent time series of area and production are derived by adjusting the official crop data as described in the text.

[a] Sesame.

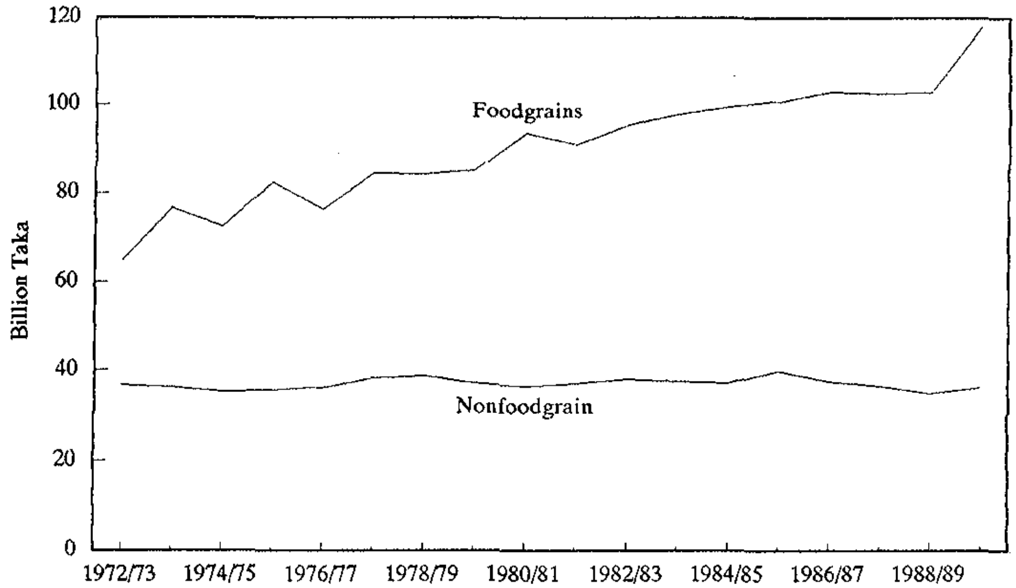
[b] Lentil.

[c] Green gram.

[d] Black gram.

* Estimated growth rate is statistically significant at the level of 5 percent or less.

Figure 2.1--Growth in gross value of production in crop agriculture

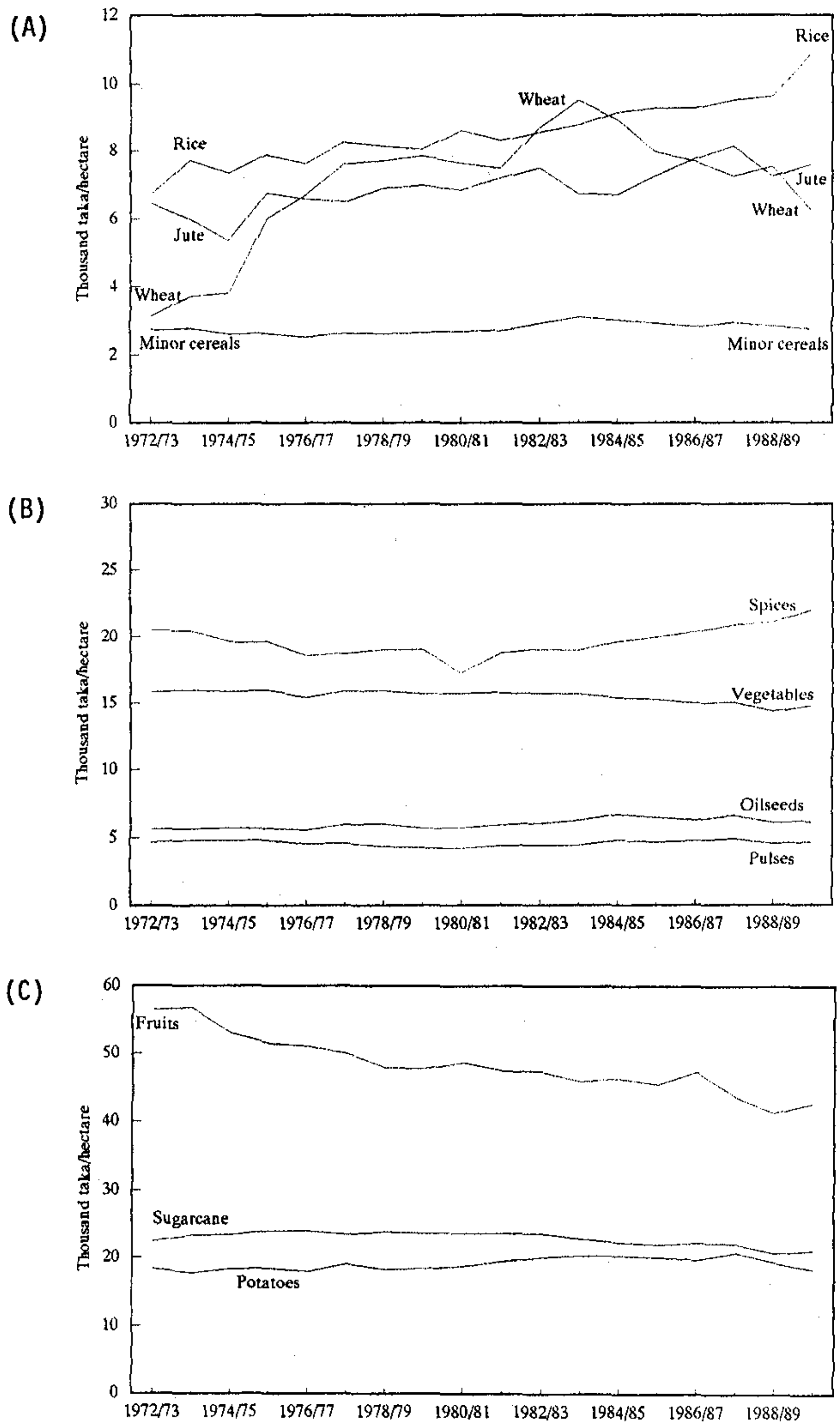


Source: Gross value of production is estimated at the trend 1985/86 farmgate prices; the estimates are the same as those underlying Table 2.1

Perhaps the only other instances of noteworthy growth performance are provided by the production trends of tea and tubers in the earlier period, although in both cases, production became virtually stagnant in the 1980s. On the other hand, the production of pulses declined, especially in the 1980s, while minor cereals exhibited the most dramatic rates of output decline.

For the crop sector as a whole, while area expansion was a source of growth in the earlier period, the entire production growth in the 1980s came from the increase in revenue yield per hectare of gross cropped land (Tables 2.1 and 2.2). For nonfoodgrain crops taken together, it is this increase in productivity per hectare that has kept the production index from falling, since there has been a significant decline in area, particularly in the 1980s. It is, however, important to note that these overall productivity improvements appear to have resulted from a reallocation of area in favor of higher-value crops rather than from yield improvements for individual crop or crop groups. High-value crops like vegetables, potatoes, fruits, and sugarcane have all gained in area (spices being the only exception), while area under low-value crops like jute, pulses, oilseeds, and minor cereals has declined, particularly in the 1980s. While gross revenue per hectare varies widely among crop groups, there is hardly any evidence of sustained improvements in such revenue yields for any of the nonfood-grain crop groups (Figure 2.2).

Figure 2.2--Crop yields: gross revenue per hectare at 1984/85 farmgate prices



Source: See Table 2.1.

Growth in the overall rice yield is almost entirely explained by the shift of area from local rice to HYVs (Tables 2.3 and 2.4). There has in fact been a significant decline in the yield rates of rainfed (aus and aman) HYVs, particularly in the earlier period. Some improvements in yields seem to have taken place only in the case of local aus and transplant aman rice in the 1980s. The major contribution to production growth has come from the expansion of area under the dry-season (boro) HYV rice, with no discernible trend in its yield rate.

Table 2.5 presents the estimates of trend growth rates of area, production, and yield for individual nonrice crops, and it is worth noting some of the statistically significant trends (see also Appendix 2, Table A2.3). Wheat production grew at a phenomenal rate of 26 percent annually during the earlier period, with both area expansion and yield improvements, but production became virtually stagnant in the 1980s. The production of potatoes also increased at a high rate (4 percent annually) in the earlier period, made possible by increases in both area and yields, but the momentum seems to have been lost in recent years. Sweet potato is a crop much favored under official policies for crop diversification, although its production rapidly declined (4 percent annually) in the 1980s. For jute, tea, and mustard (the major oilseed crop), there were some yield improvements in the earlier period that could not be sustained in the 1980s. Area under pulses declined significantly in the 1980s, but in the case of masur (lentils) this seems to have been compensated for by yield improvements. This seems also to have been the case for chilli, which is the major spice crop. Among fruits, the yield rate of mango has been falling sharply, but there has been some area expansion. Banana production became stagnant in the 1980s after experiencing some growth in the earlier period. Among vegetables, the growth of production is mainly through area expansion without much improvement in yields, if any.

AREA ALLOCATION

It would appear that the reallocation of cropped area, especially from traditional to modern varieties of rice, has been the predominant factor behind growth in crop agriculture. Determinants of area allocation, economic and physical, will be analyzed in the next chapter along with a study of the supply response in crop agriculture. Here the overall trends in the cropping pattern are examined along with changes in irrigation coverage and in the cropping intensity of land. Tables 2.6 to 2.8 present some relevant estimates regarding these trends based on five-year averages for five overlapping periods (see also Appendix 2, Tables A2.3 to A2.6).

The overall cropping intensity increased up to the early 1980s, thereafter stagnating and even declining in more recent years. This decline is perhaps not entirely explained by the floods in the late 1980s, since the estimate of gross cropped area in the postflood normal year of 1989/90 is no higher than the five-year average of the

Table 2.6--Area under crops as percent of net cropped area

Crop	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90
Foodgrains	111.04	114.19	119.72	120.52	119.31
Rice	109.40	110.61	114.02	114.31	113.06
Wheat	1.64	3.59	5.70	6.21	6.25
Nonfoodgrains	38.07	39.22	36.85	35.61	33.58
Jute	7.36	7.91	7.09	8.23	7.45
Oilseeds	7.05	7.24	6.86	6.49	6.17
Pulses	9.55	10.31	9.57	8.45	7.90
Spices	1.65	1.67	1.64	1.59	1.56
Fruits	1.51	1.57	1.66	1.71	1.77
Vegetables	1.26	1.32	1.44	1.55	1.68
(winter)	0.79	0.84	0.91	0.96	1.03
(summer)	0.47	0.48	0.53	0.58	0.65
Potato	0.96	1.01	1.15	1.19	1.23
Sweet potato	0.75	0.78	0.74	0.66	0.57
Sugarcane	1.61	1.64	1.72	1.79	1.86
Tea	0.47	0.47	0.49	0.49	0.50
Minor cereals	4.28	3.72	2.91	1.89	1.37
Others	1.62	1.58	1.58	1.57	1.53
All crops (cropping intensity)	149.11	153.41	156.57	156.13	152.89

Sources: Estimated from Table A2.4 in Appendix 2. For area under pulses, oilseeds, and minor cereals, consistent time series estimates are derived by adjusting the official crop data as described in the text.

Note: Figures are based on five-year averages of area under crops and net cultivated area.

Table 2.7--Area under rice crops as percent of net cropped area

Crop[a]	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90
Aus	35.3	34.5	34.2	32.7	29.2
Local aus	31.9	30.0	29.0	27.3	24.2
MV aus	3.4	4.6	5.0	5.3	5.0
Aman	62.5	64.5	65.8	65.0	61.7
B aman	19.1	18.1	17.1	15.2	12.6
Local T aman	37.2	38.7	38.0	37.5	34.5
MV aman	6.1	7.5	10.8	12.3	14.6
Boro	11.6	11.7	14.1	16.6	21.8
Local boro	4.9	4.4	4.2	3.6	3.3
MV boro	6.7	7.3	9.9	12.9	18.5
All rice	109.4	110.7	114.1	114.3	112.8

Source: Estimated from Table A2.5 in Appendix 2.

Note: Figures are based on five-year averages of area under crops and net cultivated area.

[a] MV = modern-variety, including both high-yielding varieties and Pajam; B = broadcast; T = transplant.

Table 2.8--Area under crops by season and irrigated area as percentage of annual net cropped area

Season/Crop	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90
			(percent)		
Aus season[a]					
Aus rice	35.3	34.5	34.2	32.7	29.2
of which: irrigated	0.8	1.0	1.3	1.6	1.6
Jute	7.4	7.9	7.1	8.2	7.5
Total[b]	43.7	43.5	42.2	41.9	37.8
Aman season[c]					
Aman rice	62.5	64.5	65.8	65.0	61.7
of which: irrigated	1.1	1.2	1.8	1.9	2.1
Total[d]	62.8	64.7	66.2	65.5	62.3
Boro season[e] and year-round					
Boro rice	11.6	11.7	14.1	16.6	21.8
of which: irrigated	10.9	10.6	11.8	13.6	17.9
Wheat	1.6	3.6	5.7	6.2	6.3
of which: irrigated	0.6	1.5	2.1	2.7	2.8
Other crops	29.5	29.9	28.4	25.9	24.7
of which: irrigated	1.6	1.9	2.1	2.3	2.5
Rabi crops[f]	(24.8)	(25.1)	(23.4)	(20.8)	(19.4)
Year-round crops[g]	(4.7)	(4.8)	(5.0)	(5.1)	(5.3)
Total	42.7	45.2	48.2	48.7	52.8
of which: irrigated	13.1	14.0	16.0	18.6	23.2
All seasons (cropping intensity)[h]	149.1	153.4	156.6	156.1	152.9
of which: irrigated	15.0	16.2	19.1	22.1	26.8

Source: Estimated from official data on irrigated area by crops. Official data for some crops have been adjusted. See also Appendix 2, Table A2.6.

Note: Figures are based on five-year averages of annual net cropped area and area under respective crops.

[a] Early wet season (April-July).

[b] Includes 50 percent of summer vegetables, 8 percent of oilseeds, summer chilli, and so forth.

[c] Late wet season (August-November).

[d] Includes cotton and 50 percent of summer vegetables.

[e] Dry season (December-March).

[f] Dry season nonfoodgrain crops such as pulses, oilseeds, spices, and winter vegetables.

[g] Includes mainly tea, sugarcane, fruits, betel nuts, betel leaves, ginger, and turmeric.

[h] Seasonal cropping intensities add up to the annual, since overlapping crops (for example, broadcast aman) as well as year-round crops are counted only once.

last period considered here. One cannot, of course, rule out the possibility of farmers' reacting to a perception of heightened risk in the postflood situation. The increase in cropping intensity in the earlier periods is entirely due to the increase in area under foodgrains (almost half of that area expansion up to the early 1980s being accounted for by wheat). On the other hand, the area under nonfoodgrain crops taken together has fallen continuously since the late 1970s, mainly due to the displacement of pulses, oilseeds, and minor cereals.

Within rice crops, the increase in area under HYV boro rice has been accompanied by an almost equal decline in the area under local aus and broadcast aman rice (taken together). This is mostly explained by the fact that the growing seasons of the latter two crops partly overlap with that of boro rice. In the case of HYV aman rice, on the other hand, the area expansion in the earlier periods appears to have taken place through an increase in total area under transplant aman (local and HYV taken together); but in the later periods, there has been a shift of area away from local transplant aman. The increase in total transplant aman area might have been due to the considerable expansion of coverage of flood control and drainage facilities that has taken place since the early 1970s, although there are considerable doubts regarding the effectiveness of these flood protection measures (Alam and Siddiqui 1989; Flood Plan Coordination Organisation 1991). In principle, the provision of flood protection makes it possible to grow transplant aman on low-lying lands that are suitable only for growing broadcast aman in the wet season. It may be noted, however, that the area under broadcast aman has fallen sharply only in the more recent periods, during which time the total area under transplant aman (local and HYV combined) has remained virtually stagnant (Table 2.7).[10]

Most nonrice crops, with the notable exception of jute, compete for land in the boro (dry) season (Table 2.8). It is, therefore, the changes in the cropping pattern and the cropping intensity in the boro season, especially in response to the provision of irrigation, that are crucial to the prospects of agricultural growth through crop diversification. For the entire period under review, irrigation expansion in the boro season appears to have been exactly matched by the increase in cropping intensity in that season. However, this conceals the decline in the more recent periods of nonirrigated cropped land in the boro season (a reversal of the earlier trend), presumably because additional irrigation has been provided partly on land already under dry-season cultivation. Between the early and the late 1980s (that is, the third and fifth five-year period under review), net addition to the dry-season cropped area was only about half of the additional coverage of irrigation (Table 2.8). This seems to have been the major factor behind the decline in area under pulses and other nonirrigated dry-season crops.

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[10] Between 1985 and 1990 alone, the net benefited area under flood control projects (that is, the area under the projects that actually needed flood protection) is estimated to have increased from 15 percent of the net cultivated area of the country to 22 percent (see Master Plan Organisation 1991, vol. 1, tables 3-16).

The major share of irrigated land is accounted for by boro rice, especially HYV boro, which is generally grown under irrigated conditions (Table 2.8). The expansion of HYV boro rice has therefore been closely linked with that of irrigation. Among nonrice crops, only wheat, potatoes, and vegetables are grown equally on both irrigated and nonirrigated land; most other dry-season crops, including the year-round crops, are grown predominantly on nonirrigated land (see also Appendix 2, Table A2.6). It is noteworthy that the area under boro rice (and under boro rice and wheat combined) has been expanding all along on nonirrigated land as well. Thus, not only does irrigation tend to displace some nonfoodgrain crops, but these crops seem to have lost ground to foodgrains even on nonirrigated land. These trends are clearly contrary to assumptions underlying the official plans for agricultural development, which project an increase in area under nonfoodgrain crops. It is necessary to show how past trends in the cropping pattern could be reversed under such a plan.[11]

INPUT USE AND PRODUCTIVITY

The adoption of the modern seed-fertilizer-irrigation technology in rice production clearly has been the main factor behind the growth in crop agriculture. To assess the trends in the contribution of these modern inputs to production growth, some productivity indicators have been estimated (Table 2.9). These productivity indicators are estimated from the increments, based on five-year averages, in land productivity in relation to the incremental changes in the use of chemical fertilizer per unit of net cultivated land and in the proportion of irrigated land out of total net cultivated land. Land productivity is measured by the gross value of crop output at constant prices (as estimated in this study) per unit of net cultivated land. It is obvious that the *incremental* productivity of an input estimated in this way incorporates the contribution of other complimentary inputs as well and should therefore be distinguished from any notion of marginal factor productivity as derived from, say, a production-function analysis. The estimated productivity indicator for irrigation can be interpreted to represent the differential in land productivity between irrigated and nonirrigated land, on the assumption that the growth in land productivity takes place entirely from the conversion of nonirrigated land into irrigated land.[12] In practice, however, overall land productivity may as well increase through improved productivity of the existing irrigated and

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[11] See, for example, the projected land allocation among crops for the Fourth Five-Year Plan (Planning Commission 1990; Ministry of Agriculture 1989b).

[12] If y_1 and y_0 are the productivity of irrigated and nonirrigated land, respectively, and r is the proportion of land irrigated, the overall land productivity is given by $y = ry_1 + (1-r)y_0$. Assuming the net cultivated land to remain constant, $\Delta y = y_1 \cdot \Delta r - y_0 \cdot \Delta r$ and therefore $\Delta y/\Delta r = y_1 - y_0$, where Δ denotes increments over time.

Table 2.9--Trends in land productivity, irrigation coverage, and chemical fertilizer use

Item	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90[a]
A. Gross value of crop output per hectare of NCA[b] (taka, 1984/85 prices)	12,580	13,380	14,214	14,993	15,478 (15,766)
B. Fertilizer use (kilograms/hectare of NCA)[c]	52.23	82.06	102.59	127.38	168.30 (163.71)
C. Area under irrigation as percent of NCA	7.09	8.12	11.29	15.86	21.10 (20.08)
D. Area under modern irrigation as percent of NCA	14.91	16.12	18.99	22.13	26.76 (26.19)
Increments over preceding period					
Item (A)		800	834	779	485 (773)
Item (B)		29.83	20.53	24.79	40.92 (36.33)
Item (C)		1.03	3.17	4.57	5.24 (4.22)
Item (D)		1.21	2.87	3.14	4.63 (4.06)
Productivity indicators (taka/hectare)[d]					
Fertilizer: (A)/(B)		27	41	31	12 (21)
Irrigation: 100 x (A)/(C)		77,670	26,309	17,046	9,255 (18,318)
Modern irrigation: 100 x (A)/(D)		66,116	29,059	24,809	10,475 (19,039)

Sources: Tables A2.1 and A2.6 in Appendix 2; fertilizer data from Bangladesh Bureau of Statistics, Monthly Bulletin, various issues.

Note: Five-year averages of items (A) to (D) are derived from the annual average of the underlying aggregate variables, for example, net cultivated land and total fertilizer use.

[a] Figures in parentheses correspond to the average of three years excluding the flood years of 1987/88 and 1988/89.

[b] NCA = net cultivated area.

[c] In terms of fertilizer materials.

[d] For interpretation, see discussion in the text.

nonirrigated land, depending on the contribution of factors other than irrigation. These estimates can therefore be taken only as a rough indicator of the impact of increased intensity of modern input use on land productivity.

The above estimates reveal some disconcerting trends in productivity. The productivity estimates for irrigation show a downward trend, whether the consideration is expansion of modern irrigation or irrigation as a whole (including irrigation by traditional methods). The estimates for the earlier periods are in fact much higher than what one would expect to find from a cross-section comparison of land productivity between irrigated and nonirrigated land.[13] This reflects the contribution of other factors to productivity growth, such as the increased cropping intensity on nonirrigated land (as took place in the earlier periods) and the shift to HYVs, especially under rainfed conditions. The declining productivity trends may mean that the contribution of these factors has diminished over time, but they also probably indicate that the productivity gains through irrigation have been on the decline.

The estimates of incremental fertilizer productivity show a sharp downward trend from the early 1980s.[14] Survey findings, based on cross-section data, generally show high returns from increased fertilizer use per unit of land, especially when such increased intensity of fertilizer use is associated with a shift from the local crop varieties to HYVs (Sidhu, Baanante, and Ahsan 1984). In the absence of consistent time-series data on crop-specific fertilizer use and yield rates, it is not possible to analyze the sources of growth in fertilizer demand and the associated changes in fertilizer productivity at the aggregate level. There are, however, at least two hypotheses, relating to the agronomic constraints to the growth of rice-based crop agriculture, that are worth mentioning in this context. First, the intensification of rice monoculture is liable to be detrimental to soil fertility, which is one reason agricultural scientists advocate crop diversification.[15] There is increasing concern in Bangladesh about the likely adverse effect on crop yields resulting from the depletion of micronutrients and organic matter in soil.[16] Second, the rapid expansion of the area under HYV boro rice may have increasingly led to its cultivation in relatively

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[13] For example, an additional boro HYV crop made possible by irrigation would yield an additional gross revenue of about Tk 16,000 at the average yield per hectare and at the 1984/85 farmgate price.

[14] These estimates may be compared with the 1984/85 farmgate price of chemical fertilizers, which was about Tk 4.80 per kilogram.

[15] See, for example, Rahman 1989 and Islam 1989; see also Pingali 1991 for a discussion in the context of Asian rice-growing countries.

[16] See Task Forces 1991, vol. 4, Environment Policy.

less suitable land.[17] Both the above hypotheses are consistent with the *apparent* declining trends in fertilizer productivity, since crop yields could be sustained only with increased fertilizer use to compensate for lower soil quality.

To assess the sustainability of growth in crop agriculture through intensified rice cultivation, it may be useful to look at the past pattern of growth in rice production, disaggregated by region. In Table 2.10, the different regions (former districts) of the country are ranked according to the rate of growth of rice production during three overlapping 10-year periods since the end of the 1960s, when HYV rice was first introduced.[18] It can be seen that the growth rate of rice production at the national level conceals strikingly large variations across regions. More important, the growth points have shifted from one period to another. While all the regions have had at least medium growth in one period or another, the early starters have generally lagged behind other regions in the later periods. The exhaustion of easy sources of irrigation is a likely reason why production growth at the regional level has not been sustained over prolonged periods. But the explanation of this may also lie partly in the hypotheses mentioned above regarding the agronomic constraints to intensified rice cultivation.

Despite these symptoms of underlying strains, the growth in crop agriculture in the immediate medium-run period will remain largely dependent on the expansion of HYV rice area under both irrigated and rainfed conditions.[19] Therefore, the physical constraints to productivity growth in crop agriculture have to be overcome to a large extent by technological innovations in rice cultivation itself. At the same time, there is a need to exploit whatever scope there is for crop diversification as a means of sustaining agricultural growth and productivity.

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[17] The Bangladesh Agricultural Research Council (BARC) maintains a system of agroclimatic land suitability classification by crops. According to this classification, about 45 to 55 percent of the land is considered to be at least moderately suitable for boro HYV rice, subject to the provision of irrigation. With the introduction of some recent HYVs, the proportion of suitable land may have increased further. However, it is not known how far the existing irrigation coverage coincides with this land suitability.

[18] The only region excluded from the exercise is Chittagong Hill Tracts.

[19] See, for example, the medium-term projections of crop production made for the National Water Plan (Master Plan Organisation 1991, vol. 2).

Table 2.10--Ranking of regions according to trend rate of growth of rice production

Annual Growth Rate Ranking	1967/68-1977/78 Region	1967/68-1977/78 Growth Rate	1973/74-1983/84 Region	1973/74-1983/84 Growth Rate	1979/80-1989/90 Region	1979/80-1989/90 Growth Rate
		(percent)				
High (above 4 percent)	Tangail	(10.56*)	Tangail	(5.77*)	Kushtia	(8.18*)
	Noakhali	(5.12*)	Pabna	(5.66*)	Jessore	(6.66*)
	Chittagaog	(4.12*)	Bogra	(5.08*)	Faridpur	(6.37*)
			Patuakhali	(4.85*)	Bogra	(4.71*)
					Rajshahi	(4.09*)
Medium (2-4 percent)	Jessore	(3.55*)	Mymensingh	(2.95*)	Dinajpur	(3.61*)
	Mymensingh	(3.52*)	Dhaka	(2.86*)	Rangpur	(3.18*)
	Dhaka	(2.27*)	Barisal	(2.59*)	Comilla	(2.83*)
	Pabna	(2.06*)	Khulna	(2.46*)	Noakhali	(2.47*)
			Rangpur	(2.15*)		
			Sylhet	(2.00)		
Low (below 2 percent)	Bogra	(1.92)	Chittagong	(1.83*)	Barisal	(1.77*)
	Barisal	(1.81)	Rajshahi	(1.80*)	Pabna	(1.67)
	Kushtia	(1.60)	Comilla	(1.34)	Khulna	(1.66)
	Rajshahi	(1.18)	Noakhali	(1.04)	Patuakhali	(1.41)
	Rangpur	(1.08)	Dinajpur	(0.77)	Mymensingh	(0.87)
	Dinajpur	(0.84)	Faridpur	(0.63)	Chittagong	(0.51)
	Comilla	(0.82)	Jessore	(0.22)	Sylhet	(-0.35)
	Khulna	(-0.36)	Kushtia	(-0.19)	Dhaka	(-0.72)
	Faridpur	(-0.79)			Tangail	(-1.12)
	Sylhet	(-3.43)				

Notes: Growth rates are estimated by fitting semilogarithmic trend lines. For all periods, Mymensingh and Barisal represent the erstwhile greater districts, respectively. However, separate estimates are also shown for Tangail and Patuakhali regions as data permit. Growth rates for 1967/68 to 1977/78 are estimated by excluding 1971/72 and 1972/73 from the time series for dissociating the adverse effects of the war of liberation. For Tangail, the estimate is based on the continuous series from 1970/71 to 1977/78.

* Estimated growth rate is statistically significant at the level of 5 percent or less.

3. CROPPING PATTERNS AND AGRICULTURAL SUPPLY RESPONSE

PHYSICAL AND TECHNICAL CONSTRAINTS

The cropping pattern systems in Bangladesh are delicately balanced by the annual cycle of rains and floods. The production options of the farmer and his perception of risk are determined to a large extent by the physical environment of crop production such as characterized by the degree of seasonal flooding, the timing and quantity of rainfall, and the soil characteristics (see, for example, Master Plan Organisation 1987a; Islam 1989). Investments in irrigation and flood control as well as improvements in crop production technology can induce changes in the cropping patterns through their impact on these physical constraints. There are large variations in the cropping patterns observed among various regions of the country, and many of these variations can be related to agroclimatic factors.[20]

The cropping patterns in the country can be broadly classified into rainfed and irrigated patterns, which again vary according to the degree of seasonal flooding. Table 3.1 presents evidence on such variations in cropping patterns, based on data from a fairly representative nationwide farm survey.[21] The land categories according to flood-depth levels are similar to those of the National Water Plan (Master Plan Organisation 1991); these are mainly based on the suitability of land for growing different rice crops during the wet season.[22] Irrigation is divided into modern and traditional; the former mainly includes mechanized irrigation by pumps and tubewells, while the latter includes labor-intensive methods requiring very little fixed investment.

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[20] These regional variations in cropping patterns are analyzed in one of the background papers of this study (Zohir 1993a); see also Rashid 1989.

[21] The farm survey was conducted in 1987 by the Bangladesh Institute of Development Studies in connection with a study on the adoption of HYV rice technology in Bangladesh agriculture; see Hossain et al. 1990. We are grateful to the authors of that study for allowing us access to the primary survey data.

[22] In the farm survey mentioned above, the information on the "normal" flooding depth was gathered from the respondent farmers at the plot level. Since there are likely to be many errors in such reporting, the estimates in Table 3.1 should be taken only as a rough guide. Detailed estimates of cropping patterns by land type are also available from the studies undertaken for the preparation of the National Water Plan (see Master Plan Organisation 1987a; 1991, vol. 1). These are, however, in the nature of hypothetical constructs based on many a priori assumptions rather than actual observation of cropping patterns across land types.

Table 3.1--Crop areas as percentage of net cultivated land, by land type, 1987

Crop	High Land: No Irrigation	High Land: Traditional Irrigation	High Land: Modern Irrigation	Medium-High Land: No Irrigation	Medium-High Land: Traditional Irrigation	Medium-High Land: Modern Irrigation
			(percent)			
Local aus	32	47	12	37	48	11
Modern-variety aus	6	12	27	6	3	14
Broadcast aman	0	0	1	12	16	6
Local transplant aman	31	50	18	55	49	44
Modern-variety aman	16	14	49	15	13	38
Local boro	0	5	1	3	3	2
Modern-variety boro	0	0	29	0	3	57
Wheat	2	42	16	5	23	5
Jute	7	12	11	11	15	6
Sugarcane	5	0	3	2	1	0
Potato	2	8	2	4	2	1
Spices	2	3	2	4	1	1
Vegetables	6	9	1	1	4	0
Oilseeds	2	1	1	5	1	2
Pulses	10	3	6	18	8	6
Orchards	20	2	0	0	0	0
Other crops	14	11	0	1	12	1
All crops (cropping intensity)	156	218	180	179	200	194
of which:						
All rice	85	128	137	128	135	172
All cereals	87	170	153	133	158	177
Noncereals	69	48	27	46	41	17
Share of land type in total land	21.86	2.66	3.32	28.06	1.86	11.75

(continued)

Table 3.1--Continued

Crops	Medium-Low Land: No Irrigation	Medium-Low Land: Traditional Irrigation	Medium-Low Land: Modern Irrigation	Low-Land: No Irrigation	Low-Land: Traditional Irrigation	Low-Land: Modern Irrigation	All Land
	(percent)						
Local aus	57	9	1	59	0	2	32
Modern-variety aus	0	25	9	1	0	1	7
Broadcast aman	46	5	24	45	2	10	15
Local transplant aman	29	19	33	12	0	4	37
Modern-variety aman	6	6	7	1	0	0	16
Local boro	2	2	6	6	9	4	3
Modern-variety boro	0	16	62	0	89	93	16
Wheat	5	19	6	6	0	0	6
Jute	5	23	2	6	0	0	7
Sugarcane	2	3	0	0	0	0	2
Potato	2	4	0	1	0	0	2
Spices	2	3	0	7	0	2	2
Vegetables	1	0	0	1	0	0	2
Oilseeds	10	0	6	7	0	1	4
Pulses	23	2	4	13	0	2	13
Orchards	0	0	0	0	0	0	4
Other crops	1	0	0	3	0	1	4
All crops (cropping intensity)	191	138	165	165	100	120	173
of which:							
All rice	140	86	142	121	100	114	126
All cereals	145	105	148	127	100	114	132
Noncereals	46	33	17	38	0	6	41
Share of land type in total land	15.07	0.54	5.41	3.79	2.35	3.33	100.00

Source: Authors' estimates based on primary data from Hossain et al., Differential Impact of Modern Rice Technology: The Bangladesh Case (Bangladesh Institute of Development Studies, Dhaka, 1990, mimeographed).

Some important features of these cropping patterns are particularly relevant for crop diversification. Irrigation appears to have a favorable impact on the annual cropping intensity on high and medium-high land but a negative impact in the case of lower lands. The higher is the land, the larger is the share of land devoted to noncereal crops within any of the irrigation categories. On the other hand, among all flood-depth levels, the proportion of land allocated to noncereal crops is markedly lower under irrigated conditions than under rainfed conditions. However, there is also a sharp contrast in the cropping patterns between modern and traditional irrigation, the latter being clearly more conducive to diversified cropping patterns.

These findings generally lend support to common wisdom regarding potential cropping patterns on different land types.[23] Many of the variations in the cropping patterns are explained by the extent of adoption of HYV boro rice, and the nature of crop substitution due to such adoption, across land types. It can be seen that HYV boro is grown almost entirely under modern irrigation (except on the lowlands, where it is also grown under traditional irrigation). However, it accounts for a declining share of modern-irrigated land, moving from lowlands to highlands (from more than 90 percent to about 30 percent). On lower lands, HYV boro tends to displace not only dry-season noncereal crops, but also broadcast aman and local aus--hence the likely adverse impact of irrigation on the annual cropping intensity. In the case of high and medium-high land, on the other hand, irrigation makes it possible to grow two or even three crops in a year, thus leading to higher cropping intensities. In contrast to the cropping patterns under modern irrigation, those under traditional irrigation on higher lands are characterized by the dominance of wheat and the near absence of HYV boro, among dry-season crops.[24] Modern irrigation can be seen to promote the adoption of not only HYV boro, but also of the HYVs in the wet season.[25] Traditional irrigation on high land appears to strengthen the cultivation not only of wheat but also of high-value noncereal crops like potatoes, vegetables, and spices. The production conditions here may not be suitable for HYV boro cultivation, which needs continuous irrigation and flooding and is therefore much more demanding on water compared with most other crops. But this still does not explain why the high-value noncereal crops cannot compete with HYV boro under modern

[23] The subject is covered in a background paper of this study (Zohir 1993b). See also Islam 1989.

[24] Unlike in the case of modern irrigation, local aus is not displaced by traditional irrigation, since it can be grown along with most dry-season crops, but not with HYV boro. This probably explains the high cropping intensity under traditional agriculture.

[25] Since HYV aman rice is mostly rainfed (Table 2.8 in Chapter 2), the simultaneous adoption of HYVs on irrigated land in both boro and aman seasons probably has something to do with farmers' technology-adoption behavior.

irrigation.[26] The answer may lie in a combination of technical and economic factors. As will be discussed later, there are very high risks associated with the marketing of these high-value crops. At the same time, the existing irrigation and on-farm water management systems do not allow rice and nonrice crops to be planted in the same service units. Growing nonrice crops under modern irrigation would therefore often require the farmer to allocate all of his land (or the major part of it) to these crops--hardly a preferable option for a risk-averse farmer. Traditional irrigation, being of a divisible nature, allows farmers to grow these high-value, but risk-prone, crops on small parcels of land. It is only when there are large economies of scale in marketing and (or) assured markets (as in the case of vegetable belts near urban centers) that noncereal crops are found to be grown under modern irrigation on any significant scale.

The currently practiced cropping patterns evidently offer little scope for crop diversification through expansion of modern irrigation. It is not surprising therefore that, in projection exercises for the crop sector, the prospects for crop diversification are often sought in more intensive cultivation of nonirrigated land (see, for example, Master Plan Organisation 1991, vol. 2). But there may not be much scope for this left, as would appear from the recent trends in cropping intensities, particularly in respect of dry-season nonirrigated crops.[27] The prospects for intensified cultivation of noncereal crops through the expansion of area under traditional irrigation also do not seem promising. The official data in fact show a declining trend in the area covered by traditional modes of irrigation (Appendix 2, Table A2.6).[28] An important policy concern in this context is the potential scope for promoting such "intermediate" irrigation technology as that represented by hand-tubewells and treadle pumps. These labor-intensive irrigation techniques are found to be particularly advantageous for small farmers and for growing crops like potatoes, vegetables, and spices.

When effective, flood control measures can also promote crop diversification by increasing the availability of "higher" land types. But, as discussed earlier, there are considerable doubts regarding the effectiveness of these flood control measures. Moreover, it is often the case that investments in flood control are profitable only when these include provision for irrigation (see, for example, Flood Plan Coordination Organisation 1991). If so, this would involve a transition from

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[26] The profitability estimates presented in Chapter 4 will show that the net returns from these crops are generally higher as compared with HYV boro.

[27] See the earlier discussion in the context of Table 2.8.

[28] No increase in the area under traditional irrigation is envisaged in the National Water Plan (1990-2005). The reason cited is that traditional irrigation modes are so inexpensive that these probably are being used whenever possible (Master Plan Organisation 1987b).

lower nonirrigated land types to higher irrigated ones--which may in fact result in more concentration on cereal production (Table 3.1).

There is considerable scope for increasing the yields of noncereal crops through better farm practices and varietal improvements even under nonirrigated or semi-irrigated conditions (Ministry of Agriculture 1989b). Such yield improvements, rather than more intensive cultivation of land, perhaps offer better growth prospects for these crops. The real prospects for crop diversification, however, would still depend on how far technological innovations could make noncereal crops competitive under conditions of modern irrigation. Research and extension activities in the past were mainly concentrated on HYV rice to the neglect of most other crops. Among noncereal crops, the HYV technology is well established only in potato cultivation. However, HYVs with very high yield potentials are now available for some vegetables and fruits like tomatoes, beans, watermelons, and bananas. Significantly improved technologies are also available for pulses, mustard, jute, sugarcane, maize, sweet potatoes and some country vegetables.[29] However, the technical and socioeconomic constraints to the diffusion of improved technologies in the case of noncereal crops are still little understood. Much will depend on how far adaptive research and extension activities can be strengthened to identify and overcome these constraints.

The cropping patterns shown in Table 3.1 do not directly reveal the nature of competition (or complimentarity) in the choice of crops in different land types. Although most nonrice crops compete for land in the dry boro season, the substitution among dry-season crops may entail changes in the choice of crops in other seasons as well. In assessing the scope for crop diversification, it may therefore be useful to look at the year-round cropping sequences associated with various competing crops or crop groups. Table 3.2 presents some information of this nature, based on data from the survey on costs and returns of crop production undertaken for the present study.[30] It can be seen that the land under HYV boro has a much lower year-round cropping intensity compared with land under other crops or crop groups. In the cropping patterns associated with HYV boro, noncereal crops account for only 2 percent of net cropped area. This may be contrasted with 38 percent in the case of cropping patterns associated with HYV aus (which competes with HYV boro because of overlapping growing seasons). Thus, in contrast to HYV boro, the adoption of HYV aus leaves considerably more room for crop diversification. However, HYV aus has relatively lower yields and is also susceptible to early seasonal floods.

Another important feature of these cropping patterns is that the noncereal crops are mostly grown along with rice, including HYV rice, on

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[29] The estimates of potential profitability of some of the improved varieties are presented in Chapter 4.

[30] The results of this survey are used in the profitability estimates in Chapter 5.

Table 3.2--Cropping patterns associated with various crops and crop groups

Cropping Pattern	Modern-Variety Aus	Modern-Variety Boro	Pulses	Oilseeds	Spices	Potato/ Sweet Potato	Vege-tables
				(percent)[a]			
Single crop	2	33	1	2	11	5	5
Double crop with							
Modern-variety rice	41	55	24	23	32	49	42
Local rice	9	2	29	22	13	4	14
Others	21	1	9	13	20	15	19
Triple crop with							
Rice only	10	7	34	35	4	21	15
Rice + others	17	1	2	5	19	5	5
All crops (cropping intensity)	225	175	235	238	212	221	215

Source: Based on S. Zohir, Scope of Crop-Diversification in Bangladesh: An Analysis with Cropping Pattern-Based Approach, Background paper of the IFPRI-BIDS Agricultural Diversification Study (Dhaka: Bangladesh Institute of Development Studies, 1993).

[a] Figures in the table are estimates of area under associated cropping patterns as percentage of net cropped area under the particular crop or crop groups.

the same land.[31] On the one hand, it shows a high degree of complimentarity in the cropping patterns between rice and noncereal crops. But, on the other hand, it also indicates that these noncereal crops may potentially compete with boro rice for the same land during the dry season. An implication of this latter aspect is that, by making noncereal crops competitive through the adoption of technology based on modern inputs, the pattern of growth in crop agriculture could be made more flexible and responsive to changing demand-supply scenarios. This would also ensure a better allocation of land, especially dry-season irrigated land, according to agroclimatic suitability.[32] There are again certain constraints to be overcome in promoting the production of noncereal crops within rice-based cropping patterns. Supplementary irrigation during the wet season may be necessary not only for promoting the adoption of summer HYVs but also for ensuring a timely aman crop that would leave room for growing dry-season noncereal crops. Selective mechanization of agricultural operations may also be needed to overcome

[31] This is hardly surprising, since about 50 percent of the arable land is estimated to be suitable for both dryland and wetland crops, and only 8 percent exclusively for dryland crops (Master Plan Organisation 1987a). Most nonrice crops as well as broadcast rice are dryland crops, while transplant rice, including the HYVs, is grown only under wetland crop culture.

[32] For example, HYV boro yields are found to be significantly lower on permeable soil types, which are also particularly suitable for growing most nonrice crops (see Zohir 1993c).

the shortage of human and bullock labor during the peak period immediately following the aman harvest.

CROPPING PATTERNS: SOME ECONOMETRIC RESULTS

Area Allocation Equation: Estimation with Cross-Section Data

As already noted, there are considerable variations in the cropping patterns across different regions of the country. Cross-section data by region are therefore suitable for an econometric analysis of the impact of various socioeconomic and environmental factors on crop area allocation.[33] For this, crop area data from the 1983-84 *Census of Agriculture* has been used for the 64 administrative districts of the country (Bangladesh Bureau of Statistics 1986). The dependent variable for the regression exercise is the area under a crop as a proportion of net cultivated area. The explanatory variables used in the regressions, the results of which are reported in Table 3.3, are defined as follows:

IRRIGATION: Irrigated crop area as a proportion of net cultivated area.

FARM SIZE: Area belonging to farms of more than 7.5 acres as a proportion of net cultivated area.

RAINFALL: Proportionate deviation of the region's average annual rainfall from the national average.

HIGHLAND: High land area as a proportion of net cultivated area.

LOWLAND: Medium-low and low land area as a proportion of net cultivated area.

The irrigation variable is estimated from the annual district-level data reported by the Bangladesh Bureau of Statistics; it corresponds to the year 1983/84 and includes both modern and traditional irrigation. The farm-size variable, which reflects regional differences in the average farm size as well as in the degree of land concentration, is estimated from data reported in the 1983-84 *Census of Agriculture*. The estimates of annual rainfall by region are based on data from 29 meteorological stations. The land categories by flood depth (for example, high land, low land) are those of the National Water Plan as discussed earlier; the up-dated data by district has been used as available from the data system maintained by the Bangladesh Agricultural Research Council.

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[33] For similar exercises in the context of adoption of HYV rice in Bangladesh, see Hossain 1988 and Mahmud and Muqtada 1988.

Table 3.3--Estimates of crop area equations from agricultural census data for 64 new districts, 1983/84

Dependent Variable: Crop Area as Proportion of Net Cultivated Area	Explanatory Variables					
	IRRIGATION	FARM SIZE	RAINFALL	HIGHLAND	LOWLAND	R^2
			Linear Function			
Modern-variety boro	0.622*	-0.279*	0.043		0.043	.73
	(10.10)	(-3.22)	(1.53)		(1.38)	
Modern-variety aus	0.103*	-0.194*	0.087*		-0.085*	.59
	(3.06)	(-4.10)	(5.60)		(-4.95)	
All aus	-0.398*	-0.670*	0.067		-0.238**	.37
	(-3.26)	(-4.09)	(1.22)		(-2.42)	
Modern-variety aman	0.335*	-0.332*	0.186*		-0.182*	.58
	(4.39)	(-3.09)	(5.31)		(-4.69)	
Local transplant aman	0.205	0.389	0.147*	-0.651*	-1.04*	.67
	(1.12)	(1.51)	(1.78)	(-6.61)	(-10.12)	
All transplant aman	0.506*		0.324*	-0.559*	-1.18*	.72
	(2.90)		(4.02)	(-5.89)	(-11.72)	
Broadcast aman	-0.748*	-0.430*	-0.116*		0.596*	.78
	(-7.86)	(-3.20)	(-2.66)		(12.30)	
Oilseeds and pulses	-0.657*		-0.168*		0.279*	.42
	(-4.87)		(-2.72)		(4.05)	
Spices	-0.108**	-0.134**	0.023	0.045**		.30
	(-2.62)	(-2.24)	(1.17)	(2.19)		
			Logit Function[a]			
Modern-variety boro	0.77*	-0.472*	.057		0.077	.58
	(6.70)	(-2.91)	(1.09)		(1.32)	
Modern-variety aus	0.105*	-0.268*	.084*		-0.089*	.57
	(2.76)	(-4.98)	(4.77)		(-4.56)	
All aus	-0.425*	-0.775*	0.062		-0.278**	.37
	(-3.10)	(-4.19)	(1.00)		(-2.51)	
Modern-variety aman	0.446*	-0.248**	0.119*		-0.236*	.60
	(6.08)	(-2.40)	(3.53)		(-6.311)	
Local transplant aman		0.451	0.342**	-0.756*	-1.465*	.54
		(0.96)	(2.20)	(-4.17)	(-7.85)	
All transplant aman	1.046*		0.520*	-1.718*	-1.746*	.65
	(3.45)		(3.73)	(-4.37)	(-10.04)	
Broadcast aman	-0.820*	-.388**	-0.127*		0.739*	.71
	(-6.07)	(-2.04)	(-2.04)		(10.73)	

(continued)

Table 3.3--Continued

Dependent Variable: Crop Area as Proportion of Net Cultivated Area	Explanatory Variables IRRIGATION	FARM SIZE	RAINFALL	HIGHLAND	LOWLAND	R^2
			Logit Function[a]			
Oilseeds and pulses	-0.751* (-4.65)	-0.364 (-1.60)	-0.296* (-4.00)		0.275* (3.34)	.44
Spices	-0.083* (-2.549)	-0.184* (3.897)		0.024 (1.461)		.24

Notes: Figures in parentheses are t-statistics. For the logit function, these refer to the corresponding coefficients of the estimated function.

[a] The estimated logit function is of the form

$$\log\left(\frac{y}{1-y}\right) = a_0 + a_i \sum X_i ,$$

where Y is the dependent variable. The reported coefficients are estimated as dY/dX_i = $a_i * Y(1-Y)$ at the mean value of Y. These coefficients are therefore comparable to those of the linear function.

* Significant at 1 percentlevel

** Significant at 5 percent level.

Definitions of variables:

- IRRIGATION: Irrigated crop area as a proportion of net cultivated area.
- FARM SIZE: Area belonging to farms of more than 7.5 acres as a proportion of net cultivated area.
- RAINFALL: Proportionate deviation of the region's average annual rainfall from the national average.
- HIGHLAND: High land area as a proportion of net cultivated area.
- LOWLAND: Medium-low and low land area as a proportion of net cultivated area.

It may be noted that the coefficients of linear regression equations involving the above variables can be given a meaningful interpretation. For example, assume that y_1 and y_0 are the proportion of land under the crop on irrigated and nonirrigated land, respectively, and that r is the proportion of total land irrigated. The proportion of total land under the crop is then given by $y = y_1r + y_0(1 - r)$, so that by differentiation, $dy/dr = (y_1 - y_0)$. Since y and r are the dependent and the explanatory variables, respectively, in the regression model, the coefficient of the irrigation variable can thus be interpreted as an estimate of the numerical difference of the proportions of land under the crop on irrigated and nonirrigated land. A similar interpretation can be given in the case of land-category variables as well. (If both HIGHLAND and LOWLAND are used in the same equation, the implied comparison in each case would be with the medium-high land as the reference category). The major problem with such a specification of the crop area equation is that it cannot capture the impact of interaction of the explanatory variables (such as between rainfall and highland) on the cropping pattern.

The area allocation equations, as specified above, are estimated by ordinary least-squares regressions. One problem in using irrigation as an explanatory variable is that both irrigation and HYV adoption may be the outcome of simultaneous decisionmaking by farmers (in which case the use of one to "explain" the other would not be legitimate). However, the expansion of modern irrigation in Bangladesh has been mostly determined by factors that lie outside individual farmer's decisionmaking. Traditional irrigation is also mostly the outcome of natural endowment of land and water rather than of a conscious investment decision by the farmer. As such, irrigation can appropriately be treated as an exogenous variable. As regards the dependent variable, since it can take a value only between zero and unity, estimates have also been attained by using a logit function as an alternative to the linear specification. Table 3.3 reports the results obtained from either specification of the crop-area equations.

The results of the regression exercise are very satisfactory, not only in terms of the statistical significance of the coefficients, but also because these generally appear to be highly plausible. For example, the crucial importance of flood-depth levels in determining the cropping pattern is clearly evident from the estimated coefficients. However, instead of taking these results as a proof of the obvious (for example, that lowland is not suitable for transplant aman), these should rather be considered as an evidence of the reliability of the existing land classification by flood-depth levels.

It is the results relating to the irrigation-induced shifts in the cropping patterns that are of particular interest for this study. The regression results in this respect are again clearly in conformity with the survey findings discussed earlier. Irrigation can be seen to have the strongest impact on the adoption of HYV boro (and the estimate of the coefficient in the range of 0.62 to 0.77 seems highly plausible). The positive impact of irrigation on HYV aus is also what one would expect; but the same result in the case of HYV aman, which is predominantly rainfed, is not obvious. This has perhaps something to do with the HYV boro-based cropping pattern, as discussed earlier in the context of similar survey findings. The results also imply that the irrigation-induced expansion of area under HYV aman would lead to an expansion of total area under transplant aman (rather than resulting from a shift away from local transplant aman). This again conforms to the earlier observation regarding the trends in the cropping patterns up to the mid-1980s (see the discussion in Chapter 2). That irrigation displaces both local aus and broadcast aman also comes out strongly from the results. Again, as expected, irrigation is seen to have a negative impact on rabi crops (pulses, oilseeds, and spices).

Rainfall appears to strongly favor the adoption of HYVs in the wet season. On the other hand, rainfall seems to have a negative effect similar to that of irrigation on the area under broadcast aman, pulses, and oilseeds. This would suggest that these crops are of a residual nature, liable to be displaced by more remunerative cropping patterns under a favorable environment. The dependence of HYV aman on rainfall (apart from the availability of suitable land by flood depth) has an important policy implication, namely, that the area under HYV aman can be expanded by providing supplementary irrigation in the rainy season, and even without requiring costly investments in flood control.

The coefficients of the farm-size variable are quite in conformity with what one would expect from an observation of the estimates of crop area allocation by farm-size groups as reported in Table 3.4. The later

Table 3.4--Area under crops as percentage of net cropped area, by farm-size group, 1983/84

Crop	Farm-Size Groups[a] Small (Below 2.5 Acres)	Medium (2.5-7.5 Acres)	Large (Above 7.5 Acres)	All Farms
		(percent)		
Local aus	40.0	36.4	29.0	35.5
Modern-variety aus	6.5	4.7	3.2	4.8
Local transplant aman	34.2	37.6	39.1	37.0
Modern-variety aman	10.9	8.2	6.1	8.4
Broadcast aman	18.2	17.5	16.2	17.3
Local boro	4.5	4.8	6.8	5.2
Modern-variety boro	14.5	10.5	9.1	11.2
All rice	128.7	119.7	109.6	119.6
Wheat	9.0	6.7	5.2	6.9
Jute	13.5	12.9	10.9	12.6
Pulses	10.8	11.5	11.0	12.6
Oilseeds	7.8	7.7	7.0	7.5
Spices	4.9	3.6	2.9	3.8
Vegetables	5.4	2.8	2.0	3.3
Potato	2.5	1.6	1.1	1.7
Sweet potato	1.1	0.7	0.5	0.7
Minor cereals	3.3	3.1	3.0	3.0
All crops (cropping intensity)	187.0	170.3	153.2	171.3

Source: Based on data from Bangladesh Bureau of Statistics, The Bangladesh Census of Agriculture and Livestock: 1983-84 (Dhaka: Ministry of Planning 1986).

Note: Net cropped area excludes area under permanent crops.

[a] The small, medium, and large farm-size groups account for 27.7 percent, 46.5 percent, and 25.8 percent, respectively, of total net cropped land under temporary crops.

estimates are also based on data from the Agricultural Census of 1983-84. The regression results show that the proportion of land under large farms generally has a negative effect on crop area, which is in part an implication of lower cropping intensity on larger farms in general. But there is also evidence in these results that the extent of HYV adoption, in terms of a shift from local varieties to HYVs, is significantly less on larger farms. This is clearly shown by the estimated farm-size coefficient for HYV aman compared with that for local transplant aman. The estimates of cropping pattern by farm size in Table 3.4 show that, for all seasons, the proportion of rice land allocated to HYVs is higher on small farms than on large farms. Among nonrice crops, there appears to be little variation among farm-size groups in area allocation for oilseeds and pulses; but the proportions of land under spices, vegetables, and potatoes are nearly twice as much for small farms as for large farms. This latter phenomenon deserves particular attention in designing policies for crop diversification.

It may be noted that in the regression exercise discussed above, it was difficult to get any reasonable estimates of area equations in respect of nonrice crops and crop groups (except those reported in Table 3.3). For certain crops, this may be because the specific agroclimatic conditions favoring the cultivation of these crops are not featured in these regressions. But another plausible implication is that the broad factors considered here are not the binding constraints in area allocation for individual nonrice crops, so that there is enough room for economic incentives and market forces to play their role in eliciting supply responses.

Area Response to Price: Estimation with Time-Series Data

The above area allocation equations estimated from cross-section data do not show the response of crop area to price changes. The flexibility of the cropping patterns in adjusting to changes in prices and profitability is an issue of considerable interest in the context of crop diversification. National-level time-series data have been used for the period 1972/73-1989/90 to estimate area response equations for a number of crops and crop groups.[34] In view of the small number of observations, a simple Nerlovian-type supply response model of the following specification is used:

$$A^*_t = b_0 + b_1P_{t-1} + \ldots + b_iX_{it} + \ldots u_t, \text{ and} \tag{3.1}$$

$$A_t = A_{t-1} + \lambda\ (A^*_t - A_{t-1}) \quad 0 < \lambda < 1, \tag{3.2}$$

[34] In the literature on the estimation of agricultural supply response, crop area is often taken as a proxy for production, since the latter is more likely to be influenced by random natural factors. Area allocation decisions are, however, of direct interest for the present study.

where

A_t and A^*_t =	actual area and planned or fully adjusted area, respectively, under the crop at time t,
P_{t-1} =	deflated harvest price of the crop lagged by one year,
X_{it} =	any other variables affecting planned area at time t, and
u_t =	random disturbance term.

The first equation is based on the assumption of naive price expectations, according to which farmers take last year's price as the expected price this year.[35] The second equation shows the process of adjustment of short-run supply to its long-run or planned level.

The reduced from of the above model is given by

$$A_t = \lambda b_0 + (1-\lambda)\ A_{t-1} + \lambda b_1 P_{t-1} + \ldots + \lambda b_i X_{it} + \ldots \lambda u_t, \qquad (3.3)$$

in which the price coefficient (λb_1) is an estimate of "short-run" price response, while the coefficient of the lagged area variable yields an estimate of the area adjustment parameter, λ. The implied estimate of the long-run price parameter (b_1) can thus be obtained.[36] The coefficients of the other explanatory variables can also be interpreted in a similar way to measure the short-run and long-run effects. If, on the other hand, instantaneous full adjustment of area is assumed (that is, $\lambda = 1$), the model is reduced to a simple Cobweb equation:

$$A_t = b_0 + b_1 P_{t-1} + \ldots b_1 X_{it} + \ldots + u_t. \qquad (3.4)$$

In this case, there is of course no distinction between short-run and long-run price responses. Equations (3.3) and (3.4) provide the two basic types of estimating equations used in this study. The choice between the two equations for a particular crop is decided empirically, depending on whether the coefficient of the lagged area variable is found to be statistically significant. In either case the estimates are based on ordinary least-squares regressions.[37] (Whenever the presence

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[35] To simplify estimation, the Nerlovian hypothesis of a recursive formation of price expectations is not pursued here. For a detailed treatment of agricultural supply response model, see Askari and Cummings 1976.

[36] It may be noted that equation (3.3) is equivalent in algebraic form to the corresponding specification of the Koyck model of geometrically lagged price expectations. The estimates of supply response derived from this equation therefore permit alternative interpretations of the long-run adjustment process. However, the error process will vary between the two models with different implications for econometric estimation (see Pyndick and Rubenfeld 1976, 211-216).

[37] As is well known, the presence of the lagged dependent variable creates problems for estimation by ordinary least-squares and for dealing with serial correlation. However, alternative estimation procedures, such as those involving the maximum-likelihood or instrumental variable techniques, may not yield better results because of the small number of observations.

of first-order or higher-order serial correlation is indicated, the estimates are adjusted accordingly.)

The price variable used in equations (3.3) and (3.4) is the harvest price of the previous year, deflated in most cases by a general harvest price index computed for this purpose. This deflated price is taken as a proxy for the relative profitability of allocating land to the crop under study compared with the alternative use of land. However, in the case of some crops directly competing with one another (for example, aus rice versus jute), a better statistical fit is obtained by using the price of the competing crop(s) as the deflator. In addition to the lagged price variable, the yield of the crop in the previous year is also used as an explanatory variable in some cases. This variable is assumed to represent farmers' perception of technical change as affecting profitability. However, since yields are also affected by natural factors, the estimated coefficient would also reflect farmer response to such random yield variations. The total area under irrigation is also considered as an explanatory variable, since irrigation is a major factor affecting the suitability of land for growing alternative crops. As discussed earlier, the expansion of irrigation in Bangladesh has been mostly determined by institutional factors that lie outside individual farmer's decisionmaking; therefore, it may be quite appropriate to treat irrigation as an exogenous variable. As regards the likely effects of weather on cropping decisions, no suitable variable can be found to capture these effects. Instead, one or two dummy variables have been used to explain the sharp changes in area in certain years, and in most cases this has allowed a better identification of the area-response functions.[38] The estimates are based on annual official data on harvest prices and area under crops.[39] However, for pulses, oilseeds, and minor cereals, consistent time series of crop area are derived by adjusting the official data as discussed in the previous chapter. In view of the weakness of the data base, the results of the present exercise need to be treated with caution.

The results reported in Table 3.5 represent the best set of estimates obtained among many variations of the estimated area equations.[40] While the lagged-price variable is included in all the estimates, the lagged-yield and irrigation variables are included, depending on whether their estimated coefficients are found statistically significant. (The estimated irrigation coefficients are not shown in the table but will be discussed later.) Where the estimated equation is of the Nerlovian form (equation 3.3), the estimates of short-run area elasticities with respect to price are shown as the main entries in the

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[38] Admittedly, the use of dummy variables in this way renders the tests of statistical significance somewhat dubious.

[39] Harvest prices are the national average of prices prevailing in the primary markets during harvesting seasons.

[40] More details of these estimates are given in a background paper of this study (Rahman and Yunus 1993). However, the results reported here incorporate some revisions.

Table 3.5--Results of estimation of area response equation for crops and crop groups

Crop (1)	Price Elasticity (2)	Yield Elasticity (3)	Lagged Area Coefficient (4)	R2 (5)	D-W Statistic (6)
Rice					
Aus	0.04***	...	...	0.94	2.20
Aman	0.36**	...	0.35**	0.97	2.18
	(0.55)				
Boro (1)	0.24**	...	...	0.98	1.62
Boro (2)	0.50**	...	0.83**	0.97	2.50
	(2.86)				
All Rice	0.06***	0.15*	...	0.88	1.72
Wheat	0.61*	...	0.88*	0.98	2.21
	(5.24)				
Jute	0.49*	...	0.28*	0.97	2.12
	(0.68)				
Sugarcane	0.15*	...	0.79*	0.96	1.89[a]
	(0.73)				
Oilseeds					
Mustard	0.13*	...	0.52*	0.93	2.05
	(0.27)				
Linseed	0.11**	...	0.66*	0.88	2.73
	(0.32)				
Til (sesame)	0.25**	...	0.75*	0.95	2.41
	(0.98)				
All oilseeds	0.16**	...	0.14*	0.923	1.85
Pulses					
Masur (lentil)	0.07***	...	0.93*	0.91	2.03[a]
	(1.09)				
Matar	0.05***	0.21***	0.96*	0.99	1.94
	(1.20)	(4.86)			
Mashkalai	0.11***	0.85*	0.88*	0.99	2.22
	(0.91)	(7.27)			
Khesari	0.04**	...	0.84*	0.94	2.54
	(0.25)				
All pulses	0.11***	...	0.81*	0.92	...
Spices					
Chilli	0.05*	...	0.68*	0.88	2.12
	(0.17)				
Onion	0.05**	...	0.45**	0.70	1.89
	(0.09)				
Garlic	0.001***	...	0.38**	0.82	1.73
	(0.01)				
Turmeric	0.03*	0.34*	0.42**	0.97	2.36
	(0.05)	(0.59)			
Ginger	0.04**	...	0.90*	0.94	1.96a
	(0.45)				

(continued)

Table 3.5--Continued

Crop (1)	Price Elasticity (2)	Yield Elasticity (3)	Lagged Area Coefficient (4)	R2 (5)	D-W Statistic (6)
Vegetables					
Brinjal	0.03**	0.32*	0.69*	0.94	1.72
	(0.08)	(1.04)			
Arum	0.30***	...	...	0.90	1.49[a]
Cauliflower	0.07*	...	0.86*	0.99	1.69[a]
	(0.51)				
Cabbage	0.08*	0.48*	0.74*	0.99	1.95
	(0.28)	(1.83)			
Tomato	0.08**	...	0.72*	0.96	2.40
	(0.29)				
Radish	0.16**	2.83*	...	0.85	2.20
Beans	0.10**	...	...	0.95	1.82[a]
	(0.51)				
Potato	0.01**	...	0.94*	0.99	1.66[a]
	(0.21)				
Sweet potato	0.08***	2.27*	...	0.82	1.94[a]
Melon	0.23*	...	0.49**	0.84	2.23
	(0.45)				
Tobacco	0.23*	1.87*	...	0.93	2.02
Cotton	0.16***	0.34**	...	0.69	1.61
Maize	0.09**	...	0.94*	0.99	2.13
	(1.58)				
Barley	0.19**	...	0.93*	0.99	1.89
	(2.79)				

Notes: The estimates are based on 17 observations. The coefficient of lagged area in column (4) refers to the Nerlovian equation (equation 3.3 in the text). The absence of an entry in column (4) indicates that the estimates are based on Cobweb equation (equation 3.4). The main entries in columns (2) and (3) show the estimated short-run area elasticities with respect to price and yield respectively, while long-run elasticities are shown within parentheses. Boro (1) and (2) represent estimates obtained with and without the irrigation variable respectively.

[a] Estimates are adjusted for first-order or higher-order serial correlation.

* Significant at the 1 percent level.

** Significant at the 5 percent level.

*** Significant at the 10 percent level.

table, while the implied long-run elasticities are shown in parentheses. The area elasticities with respect to yield are similarly shown. Also shown in the table are the estimated coefficients of the lagged area variable, on the basis of which the long-run elasticities are computed. On the other hand, the absence of any entry for the lagged area coefficient in the table indicates that the estimates are based on the simple Cobweb specification (equation 3.4), in which case there is also no distinction between short-run and long-run elasticities. It may be noted that all the elasticities are computed at the mean value of the respective variables.

The estimates presented in Table 3.5 are in respect of both individual crops and some crop groups. The estimates for "all rice" refer to total gross area under rice, while for oilseeds and pulses, all the major varieties are aggregated to obtain estimates for the respective crop groups. In most cases, the price deflator used is a general harvest price index that covers a large number of crops and is constructed by using Laspeyres' formula with 1985/86 as the base.[41] However, for "all rice," a better regression fit is obtained by using a price deflator that excludes rice (that is, a nonrice harvest price index). Similar price indices are also constructed for the crop groups (that is, pulses and oilseeds), and are then deflated by the general harvest price index. (Trends in the harvest prices of crops and crop groups will be discussed later in this chapter.) In the case of jute and aus rice, which are competing crops, their prices are deflated by each other. For wheat, the best estimate is obtained when the price of boro rice is used as the deflator.

In spite of the doubtful quality of data and the highly simplified analytical framework, the econometric results obtained for most crops are very satisfactory. The explanatory power of the estimated equations are generally high and the estimated parameters mostly conform to a priori expectations. The Durbin-Watson statistic either indicates absence of serial correlations or lies in the inconclusive range in most cases. The estimated price coefficients in nearly three-fourths of the cases are statistically significant at the level of 5 percent or less, although the short-run price elasticities are generally low. In many cases, the estimates of the lagged-area coefficient is very high, thus implying a value of long-run price elasticity that can be several times higher than the short-run one. This raises some doubts as to whether the lagged area term in the estimated equation might as well serve as a proxy for previous adjustments to some excluded variables. The estimates of relatively high long-run price elasticities are therefore suspect in some cases.

There appears to be hardly any price response in the case of total rice area or aus area, but both boro and aman rice show some degree of price responsiveness. The short-run price elasticity for boro varies from 0.24 to 0.50 depending, respectively, on whether the price effect

[41] This index appears under the head "All Crops" in Appendix 2, Table A2.7.

is controlled for irrigation or not. These results suggest that the rice crops may respond to seasonal rice prices and that such a response may involve substitution among rice crops (thus canceling out the effect at the aggregate level). The estimated short-run price response for wheat, jute, tobacco, and melon is fairly modest and of high statistical significance. Sugarcane and oilseeds also show statistically significant price elasticities, although of relatively low magnitudes. For most other crops, the price responses are weak in terms of the magnitudes of short-run price elasticities and (or) in terms of the statistical significance of the estimated price parameters.

The explanation for the weak supply response in the case of such low-value crops as pulses, oilseeds, and minor cereals may be that the choice of these crops in the rice-based cropping patterns is mostly of a residual nature. However, this cannot be a plausible explanation in the case of such high-value crops as spices, potatoes, and vegetables. The problem may instead lie in the extremely high price fluctuations that often characterize the markets for these products, thus inhibiting any rational price expectations. (The evidence on this will be discussed later in this chapter.) It cannot be argued that the price fluctuations themselves are caused by Cobweb-type supply responses, since such a price response, even if present, seems to be rather weak in most cases. The reason for supply instability may in fact lie elsewhere.[42] Survey findings suggest that the high-value, but risk-prone, crops are generally grown on small parcels of land and are usually rotated from year to year within the rice-based cropping patterns (see, for example, Islam 1989, 212). By and large, it may not be the same set of farmers who produce these crops in different years. There is thus an element of randomness in the choice of these crops that may make supply both unstable and nonresponsive to price. If so, greater specialization through the adoption of improved production technologies for these crops would probably lead to a more stable supply-response behavior.

For a number of crops, the response of area to yield changes is found to be strong and statistically significant. In nearly all of these cases, the estimated yield elasticities are several times higher than the price elasticities. This suggests that farmers respond much more strongly to yield improvements (or declines) than to price changes. This gives an added importance to policy measures supporting technological improvements for high-value crops such as vegetables and spices. Such technological improvements would contribute to the growth of the crop sector not only through increased yields, but also through the induced shift of land toward these high-value crops.

Finally, the irrigation variable is found to have a strong effect on area allocation for some crops and crop groups. (In each of these cases, the estimated irrigation coefficient is statistically significant at less than the 1 percent level.) The irrigation coefficient, which is a measure of the change in area under the crop as a proportion of the

[42] Natural factors affecting crop yields are also a likely source of supply instability.

change in total irrigation, is estimated to be –0.35 for aus, 0.79 for boro, –0.08 for pulses, and –0.04 for oilseeds. In the latter two cases, the estimates refer to the respective crop groups. These estimates, in numerical terms, are highly plausible and are consistent with the earlier findings that the expansion of modern irrigation strongly favors HYV boro cultivation, while local aus, pulses, and oilseeds are almost entirely substituted for by such irrigation.[43]

MARKETS, PRICE FORMATION, AND DEMAND-SUPPLY BALANCE

Role of Markets

Agricultural marketing and the associated storage and processing functions are crucial to agricultural supply responses and prospects for crop diversification. There are likely to be considerable variations across agricultural commodities in the degree of market integration, reliability of price formation, and the extent of market participation by farmers. While the marketing of rice has been a subject of frequent investigation in Bangladesh, there is far less information available about the marketing of other crops.[44]

Some information about the disposal by farm households of agricultural output by crop is pieced together here using unpublished primary data from the 1988/89 round of the household expenditure survey conducted by the Bangladesh Bureau of Statistics.[45] The estimates in Table 3.6 show that, compared with rice, the proportions of output marketed are generally much higher for other crops. The marketing proportions for cash crops (for example, jute and oilseeds) are high for obvious reasons, but the proportion may also be high if production is geographically concentrated (for example, wheat and potatoes) and (or) if the urban consumer demand is relatively high compared with rural demand. Per capita consumption of most agricultural products is found to be significantly higher in urban areas compared with rural areas, while the reverse is true in the case of rice consumption (Asaduzzaman 1989).

Computations with the unpublished household expenditure survey data also show that, compared with rice, poorer farm households account for a much larger share of marketed surplus of nonrice crops. This may be, in part, because of higher allocation of land to nonrice crops on smaller farms, as in the case of vegetables, potatoes, and spices (Table 3.4). But this also reflects, in part, the pattern of own-consumption of rice and other food crops by poorer and richer farm households, as

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[43] Since the increases in irrigated area are entirely due to the expansion of modern irrigation, the estimates would mainly reflect the effect of modern irrigation only.

[44] See Maziruddin 1989 for a discussion of the agricultural marketing system in Bangladesh.

[45] These data relate to production and income generation, which are not the main focus of the household expenditure survey. The estimates reported here are due to Francesco Goletti to whom we are grateful.

Table 3.6--Proportions of agricultural output marketed and self-consumed by farm households, 1988/89

Crop	Percentage Disposal of Output		
	Self-consumed	Marketed	Year-end
		(percent)	
Paddy	53.6	38.7	7.7
Wheat	43.4	51.3	5.3
Jute	13.6	84.1	2.3
Mustard	33.6	62.9	3.5
Sesame	20.1	76.3	3.6
Pulses	44.2	50.3	5.5
Potato	36.6	60.4	3.0
Minor cereals	18.3	76.8	4.9
Vegetables			
Brinjal	35.7	64.3	...
Arum	38.4	61.6	...
Pumpkin	64.8	35.2	...
Other vegetables	58.5	41.5	...

Source: Estimated from unpublished primary data of the 1988-89 Household Expenditure Survey conducted by the Bangladesh Bureau of Statistics.

dictated by the relative income elasticities of demand for these products. The estimates show that for certain items like vegetables and spices, small farms may in fact have a larger quantity of marketed surplus, in absolute terms, compared with large farms. If so, the impact of improved marketing and price incentives on the supply-response behavior of smaller farms and on their incomes deserves particular consideration in the context of policies for crop diversification.

Perhaps the most important aspect of agricultural marketing in relation to prospects for crop diversification is the extent of year-to-year price fluctuations and the associated risks to farm incomes. Using the official series of average annual harvest prices of crops, the trend annual growth rates of these prices and the average variability around the respective trend have been estimated (Table 3.7). Average variability is defined as the annual average of percent deviation (positive and negative signs ignored) of the observed prices from the estimated trend level. The corresponding estimates for the annual wholesale-level prices have also been derived, so far as data permit (these estimates are shown in parentheses in Table 3.7). The estimates show that, compared with foodgrains, the price variability is higher for all nonfoodgrain crops (with the lone exception of sugarcane), and is in fact strikingly high for many crops. The estimates mostly fall in the range of 5-6 percent

Table 3.7--Trends and variability of harvest prices of agricultural commodities, 1976/77-1986/87

Crops	Trend Annual Growth Rate[a]	Average Variability Around Trend[b]	R^2 of Fitted Trend Line
		(percent)	
Paddy			
Aus	11	7	.95
Aman	10	5	.96
Boro	9 (10)	6 (7)	.94 (.93)
Wheat	9	5	.96
Pulses			
Masur	13 (12)	11 (10)	.89 (.88)
Mung	13 (12)	14 (10)	.86 (.88)
Kheshari	13 (13)	13 (16)	.84 (.88)
Mashkalai	14 (8)	12 (6)	.90 (.93)
Oilseeds			
Rape and mustard	8	10	.83
Linseed	9	8	.90
Til	8	13	.73
Groundnut	11	10	.88
Spices			
Chili	8 (5)	35 (30)	.34 (.20)
Onion	13 (15)	19 (27)	.75 (.71)
Garlic	16	37	.56
Turmeric	13 (12)	41 (35)	.50 (.52)
Ginger	15	22	.77
Vegetables			
Brinjal	14 (12)	18 (8)	.82 (.93)
Pumpkin	14	12	.89
Cauliflower	14	17	.85
Cabbage	9	27	.46
Tomato	15	19	.79
Radish	6	23	.26
Cucumber	14	24	.69
Water gourd	17	15	.89
Beans	15	13	.88
Patal	14	15	.88
Lady's finger	12	15	.79
Jhinga	14	11	.88
Karala	14	14	.87
Arum	12	17	.76
Fruits			
Banana	13	15	.87
Mango	8	39	.26
Melon	16	23	.79
Potato	10 (9)	16 (11)	.66 (.77)
Sweet potato	13	9	.92
Sugarcane	8	4	.96
Jute	6	28	.22
Tobacco	5	15	.43

(continued)

Table 3.7--Continued

Source: Estimates are based on price data available from the publications of the Bangladesh Bureau of Statistics.

Notes: Harvest prices are those prevailing in the primary markets during harvesting seasons. Figures in parentheses correspond to wholesale-level prices, which are annual averages of urban centers.

[a] Estimated by fitting semilogarithmic trend lines.

[b] Annual average of absolute percent deviation of observed price from the estimated trend level.

for foodgrains, 10-12 percent for oilseeds and pulses, 15-25 percent for fruits and vegetables including potatoes, and 20-40 percent for spices. Evidently, for many of the items in the later groups, the price variability is too high to allow any "rational" price expectations.

The estimates presented in Table 3.7 also suggest that the variability of harvest prices is generally higher than that of the annual wholesale prices. Thus the price shocks seem to be most severe at the level of primary markets during the harvest seasons. On the other hand, there is some evidence of harvest prices growing at a generally higher trend rate compared with the respective wholesale prices; this would indicate a decline in marketing spreads over time, perhaps due to improved marketing and storage infrastructure. The evidence for this is, however, too weak to permit any firm conclusion.

Apart from the degree of year-to-year price variability, another important aspect of agricultural marketing is the extent of correlation between price movements across spatially separated markets. A high correlation is an indicator of a high degree of market integration, which characterizes an efficient marketing system. To test for integration of markets for agricultural commodities in Bangladesh, the movements in annual average wholesale prices of selected agricultural commodities were correlated between pairs of markets, using annual wholesale price data for seven urban markets spread throughout the country for selected agricultural products, as reported in publications of the Bangladesh Bureau of Statistics. These products are the most important ones among the respective groups of agricultural commodities, namely, foodgrains, pulses, oilseeds, spices, and tubers and vegetables. To correct for the effects of inflation in the time-series data, the intermarket price correlations were computed from annual price changes (that is, first differences) rather than from actual prices. The time period covered is from 1972/73 to 1988/89.

Table 3.8 provides a convenient summary presentation of the pairwise correlations of price changes for the above commodities (for a similar form of presentation, see Timmer, Falcon, and Pearson 1983, chap. 4). The distribution of price correlations suggests that the degree of integration of agricultural commodity markets is fairly high,

Table 3.8--Correlation of annual movements of wholesale prices of selected agricultural commodities among pairs of markets

Correlation Coefficient Interval	Proportion of Total Number of Coefficients by Commodity							
	Rice[a]	Masur[b]	Khesari[c]	Mustard	Onion	Chilli	Potato	Brinjal
0.95-1.00	0.36	0.25	0.39	0.25	0.43	0.39	0.32	0.25
0.90-0.94	0.25	0.07	0.25	0.04	0.21	0.50	0.07	0.07
0.85-0.89	0.21	0.04	0.11	0.07	0.14	0.11	0.14	0.00
0.80-0.84	0.11	0.11	0.07	0.07	0.07	0.00	0.04	0.04
0.75-0.79	0.07	0.25	0.00	0.04	0.11	0.00	0.07	0.00
0.70-0.74	0.00	0.07	0.07	0.00	0.04	0.00	0.14	0.00
0.65-0.69	0.00	0.07	0.00	0.11	0.00	0.00	0.07	0.04
0.60-0.64	0.00	0.00	0.04	0.07	0.00	0.00	0.00	0.00
0.55-0.59	0.00	0.07	0.00	0.04	0.00	0.00	0.07	0.07
0.50-0.54	0.00	0.04	0.07	0.04	0.00	0.00	0.04	0.04
<0.50	0.00	0.04	0.00	0.28	0.00	0.00	0.04	0.50
Total	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
First Quartile	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00	0.95-1.00
Second Quartile	0.90-0.94	0.75-0.79	0.90-0.94	0.65-0.69	0.90-0.94	0.90-0.94	0.85-0.89	0.50-0.54

Source: The price data are from the publications of the Bangladesh Bureau of Statistics.

Notes: For each commodity, the number of correlation coefficients (that is, market pairs) is 21, involving a total of 7 markets.

[a] Medium-quality rice.

[b] Lentil.

[c] A pulse variety.

but that it varies considerably among commodities.[46] It can be seen that, for all the commodities considered, at least 25 percent of the correlation coefficients are above 0.95, and at least 50 percent are above 0.85 except for masur (lentil), mustard, and brinjal (as can be seen from the estimates of the first and second quartiles). While this reflects competition and price arbitrage, it does not rule out the

[46] A correlation coefficient of 0.90, for example, means that 81 percent of the variation in one price series is correlated with the variation in the other price series.

possibility of high year-to-year price fluctuations such as those observed in the case of spices. As expected, market integration is relatively low for brinjal (representing vegetables), with 50 percent of the correlation coefficients lying below 0.54. An implication of this relatively low market integration for vegetables is that the extent of year-to-year price variations at the local or regional level may be even more severe than is shown by the estimates in Table 3.7 based on national average prices. Nevertheless, even in the case of vegetables, the estimates of intermarket correlations suggest that a domestic marketing system does exist and that it seems to connect at least some regions of the country.

Trends in Prices and per Capita Availability

The pattern of agricultural supply response interacts with the price trends and the demand-supply balance across domestic markets for agricultural commodities. The nature of these interactions has largely determined the trends in prices and per capita availability of agricultural and related products in the economy. It may be noted that international trade in most of these products has been subject to either quota restrictions or an outright ban. The prices have been therefore mostly determined domestically without any direct links with movements in international commodity prices (except in the obvious case of such export items as raw jute). International trade, however, affects supply and, thereby, domestic price formation. While the trends in domestic-versus-border prices of agricultural commodities will be examined in the next chapter, here the broad trends in harvest prices and per capita availability of agricultural commodities are addressed.

Table 3.9 shows the trends, based on five-year averages, in production, trade, and per capita availability of some selected commodities that are of particular interest for the present study. (The estimated time-series of per capita availability, along with the estimates of population and per capita GDP, are given in Appendix 2, Table A2.8.) The estimates no doubt suffer from many data deficiencies that call into question the quality of all the official crop statistics. There are major discrepancies between these estimates and the estimates of per capita consumption derived from the various rounds of the official household expenditure survey--this does not, however, render the latter estimates any more credible than the former.

It would appear from Table 3.9 that though foodgrain imports (total of rice and wheat) as a proportion of total domestic supply declined in the 1985/86-1989/90 period, there has not been a decline in imports in absolute quantity terms. However, the situation in the more recent years, not captured in the five-year average, would give a more optimistic picture regarding foodgrain self-sufficiency, particularly in rice. In edible oils, in spite of stagnant domestic production, per capita availability appears to have increased very rapidly in 1989-92 because of increased imports. (However, this abrupt increase may conceal imports used for industrial purposes.) There were no imports of sugar up

Table 3.9--Trends in production, trade, and per capita availability of selected commodities (five-year averages)

Commodity[a]	1973/74-1977/78	1979/80-1983/84	1985/86-1989/90
Rice			
Production	12,136	13,795	15,852
Import	254	314	270
Per capita availability	383.8	382.0	386.9
Wheat			
Production	211	1,038	1,019
Import	1,344	1,597	1,692
Per capita availability	53.3	77.4	70.8
Edible oil[b]			
Production	89	94	93
Import[c]	64	121	383
Per capita availability	5.2	6.5	12.6
Sugar and gur			
Production			
Sugar	119	154	147
Gur[d]	365	362	375
Import			
Sugar	18	6	137
Per capita availability			
Sugar	4.7	4.8	7.5
Gur	12.6	10.9	10.0
Vegetables			
Production	739	844	953
Export	...	1	8
Per capita availability	24.1	24.0	23.9
Tubers[e]			
Production	1,569	1,788	1,675
Per capita availability	49.6	49.4	41.1
Potato	26.3	29.4	27.5
Pulses			
Production	623	578	511
Import	...	...	43
Per capita availability	20.9	17.0	14.4

Source: Table A2.8 in Appendix 2.

Note: Leaders (...) denote insignificant quantities.

[a] Production, import, and export are in 1,000 metric tons; per capita availability is in grams per day. Per capita availability includes stock buildup.

[b] Includes edible oil used for industrial purposes.

[c] Includes oil made from imported seed.

[d] Raw sugar manufactured by traditional methods.

[e] Includes potato and sweet potato.

to the early 1980s, but in 1989-92 the volume of imports was almost as large as domestic production of refined sugar. As a result, per capita availability of sugar has increased, but this has to some extent compensated for the decline in the availability of gur (raw sugar produced by traditional methods).

The availability of vegetables in per capita terms appears to have remained almost unchanged over the years, with domestic production growing almost at the rate of population growth. There has been some export of vegetables since the early 1980s, but the annual volume of export has been less than 1 percent of domestic production on average. There is again no significant trade in potatoes, so the growth in domestic availability reflects trends in domestic production; per capita availability increased up to the early 1980s but has declined since then. And finally, there is a very clear downward trend in per capita availability of pulses along with the decline in domestic production. This has been so in spite of some imports in recent years.

The trends in deflated harvest price indices of major crops and crop groups, based on three-year moving averages, are shown in Tables 3.10 and 3.11 (see also Figure 3.1). The harvest prices are the same as used in the earlier estimates of supply-response equations; in each case, the official wholesale price index is used as the deflator.[47] As can be seen from these estimates, the real paddy price fell sharply during the mid-1970s; there were some further declines, although of lesser magnitudes, in the mid-1980s and toward the end of the 1980s. The wheat price generally followed the same trends. These price trends may seem somewhat at variance with the estimates of per capita availability, which do not provide much evidence of supply growing ahead of demand.[48] Nevertheless, these trends point to the possibility of further declines in the real price of rice, as the country is nearing self-sufficiency in rice.

The prices of pulses and vegetables in real terms can be seen to have increased very substantially over the years. In the case of pulses, this reflects the marked decline in per capita availability, while in the case of vegetables, the explanation for price trends may lie in a relatively high income elasticity of consumer demand (since per capita availability has remained virtually unchanged). In contrast to these price trends, the prices of oilseeds have registered a markedly declining trend, which is a result of increasing imports leading to higher availability of edible oils. An increasing reliance on imports is also likely to have been the main factor in keeping real prices from rising in the case of some products such as spices and sugar. A sharp decline in the price of potatoes up to the early 1980s is associated

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[47] The harvest price indices of crop groups are constructed by using Laspeyres' formula with 1985/86 as the base year. The price index for paddy is based on harvest prices of boro, aus, and aman paddy. See Appendix 2, Tables A2.7 and A2.9.

[48] There are a number of issues involved here, ranging from the reliability of foodgrain statistics to the possible worsening of income distribution that would depress foodgrain demand.

Table 3.10--Trends in deflated harvest price indices of paddy and selected crop groups (three-year moving averages)

Year	Paddy	Pulses	Oilseeds	Spices	Vegetables
1973/74	144	82	140	109	72
1974/75	140	84	142	113	78
1975/76	133	72	134	109	71
1976/77	112	70	118	94	72
1977/78	115	70	114	94	82
1978/79	116	75	108	91	98
1979/80	116	86	107	100	102
1980/81	112	92	105	100	93
1981/82	112	95	100	99	77
1982/83	114	89	101	97	82
1983/84	115	81	102	107	86
1984/85	110	86	106	114	97
1985/86	110	91	97	110	98
1986/87	110	98	95	115	95
1987/88	112	107	95	113	106
1988/89	104	108	92	109	100

Source: Table A2.7 in Appendix 2.

Note: Trends are estimated by deflating the respective harvest price indices by the general wholesale price index; all price indices have 1985/86 as the base year.

Table 3.11--Trends in deflated harvest price indices of selected agricultural commodities (three-year moving averages)

Year[a]	Wheat	Masur	Mustard	Onion	Chilli	Sugarcane	Jute	Potato
1973/74	152	73	142	79	234	95	107	151
1974/75	148	76	145	96	259	103	96	156
1975/76	132	69	139	75	261	109	111	124
1976/77	105	70	122	73	196	106	135	111
1977/78	109	74	115	66	192	105	144	106
1978/79	106	76	106	78	165	104	128	106
1979/80	108	88	104	100	175	105	104	104
1980/81	114	95	101	110	173	104	93	85
1981/82	119	98	96	107	170	101	108	73
1982/83	117	89	95	81	175	94	114	79
1983/84	109	77	95	78	207	88	154	84
1984/85	100	81	101	84	201	89	144	98
1985/86	101	92	96	93	162	93	122	100
1986/87	102	102	95	107	147	96	91	96
1987/88	103	106	93	112	156	94	87	113
1988/89	101	103	87	109	163	103	105	105

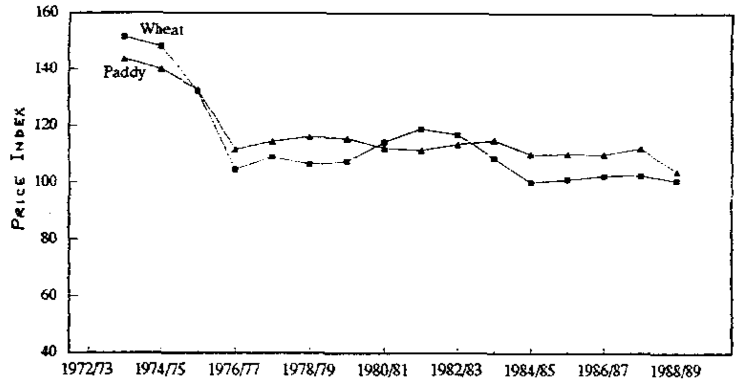
Source: Tables A2.7 and A2.9 in Appendix 2.

Note: Trends are estimated by deflating the respective harvest price indices by the general wholesale price index; all price indices have 1985/86 as the base year.

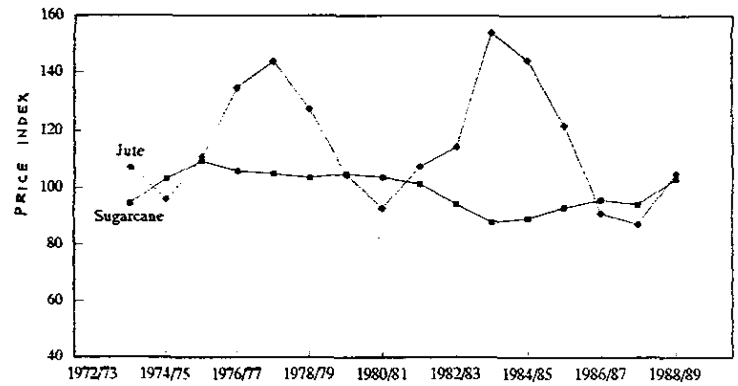
[a] The central year of the moving average.

Figure 3.1--Trends in deflated harvest price indices of various crops (three-year moving averages: base, 1985/86)

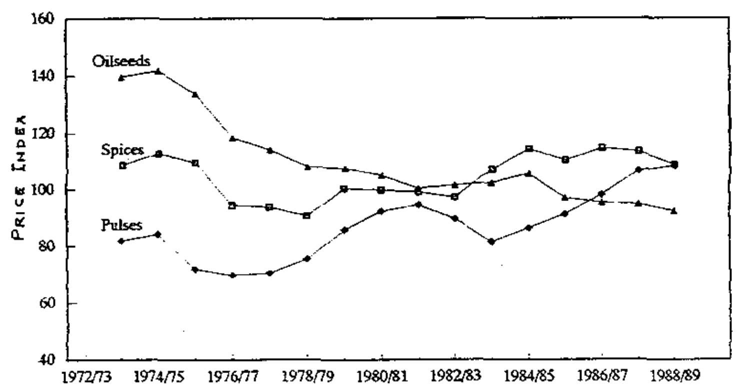
(A) Paddy and Wheat



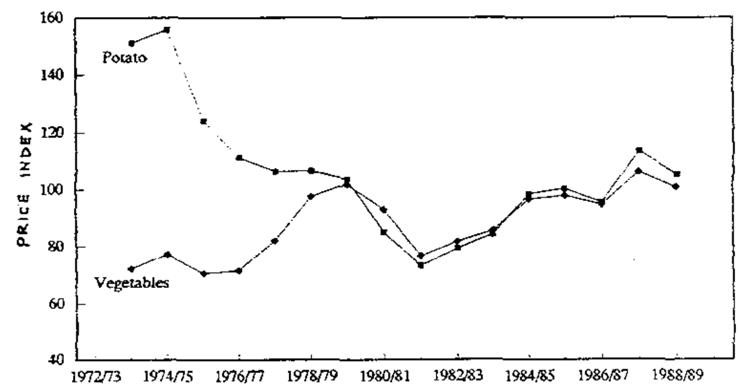
(C) Jute and Sugarcane



(B) Oilseeds, Spices, and Pulses



(D) Potato and Vegetables



with a rapid increase in per capita availability, but from then on the trends are reversed. Unlike in the case of other commodities, the domestic price of jute is linked to the price in the world market; it shows large cyclical variations that often characterize the international commodity markets.

Figure 3.2 represents an attempt to depict schematically the different outcomes of interaction between supply response and price movements in agricultural commodity markets in Bangladesh. In each case, there is an outward shift in demand, from D_1 to D_2, due to increases in population and per capita income. The short-run supply curve may, however, shift either way (from S_1 to S_2) depending on how area allocation and yields are affected by changes in such quasi-fixed factors as farmer knowledge, irrigation facilities, and well-adapted seed varieties. As a result of the shifts in supply and demand, the equilibrium in the market moves over time from A to B with the consequent changes in the price and output levels. The three alternative outcomes depicted in Figure 3.2 can be said to represent the markets for pulses, potatoes, and vegetables, respectively. These three representative cases for noncereal crops were chosen to illustrate the varying prospects of crop diversification under alternative supply-response behavior. All the cases represent a closed-economy situation with no significant foreign trade.[49]

In the case of pulses, the short-run supply curve has shifted backward as a result of the spread of irrigated agriculture; consequently, there has been a decline in output along with a price increase. In the case of potatoes, on the other hand, the supply curve has shifted outward to such an extent that the price has fallen as the output has expanded. This was the case during the period from the early 1970s to the early 1980s when potato production increased at the trend annual rate of about 4 percent (see Table 2.5) and the price in real terms declined rapidly. The shift in the supply curve was induced by technological innovations (that is, adoption of HYVs) and possibly by the spread of irrigation. And lastly, in the case of vegetables, there has been an outward shift in the supply curve, but not to the extent of the shift in demand, so that the price has increased along with the growth of production.[50] Clearly, it is the second scenario (that is, the case of potatoes up to the early 1980s) that has the most favorable outcome in terms of the growth of production, barring the case of growth through exports. Technological innovations that help to shift the supply curve outward can be seen to play the most crucial role in such a scenario.

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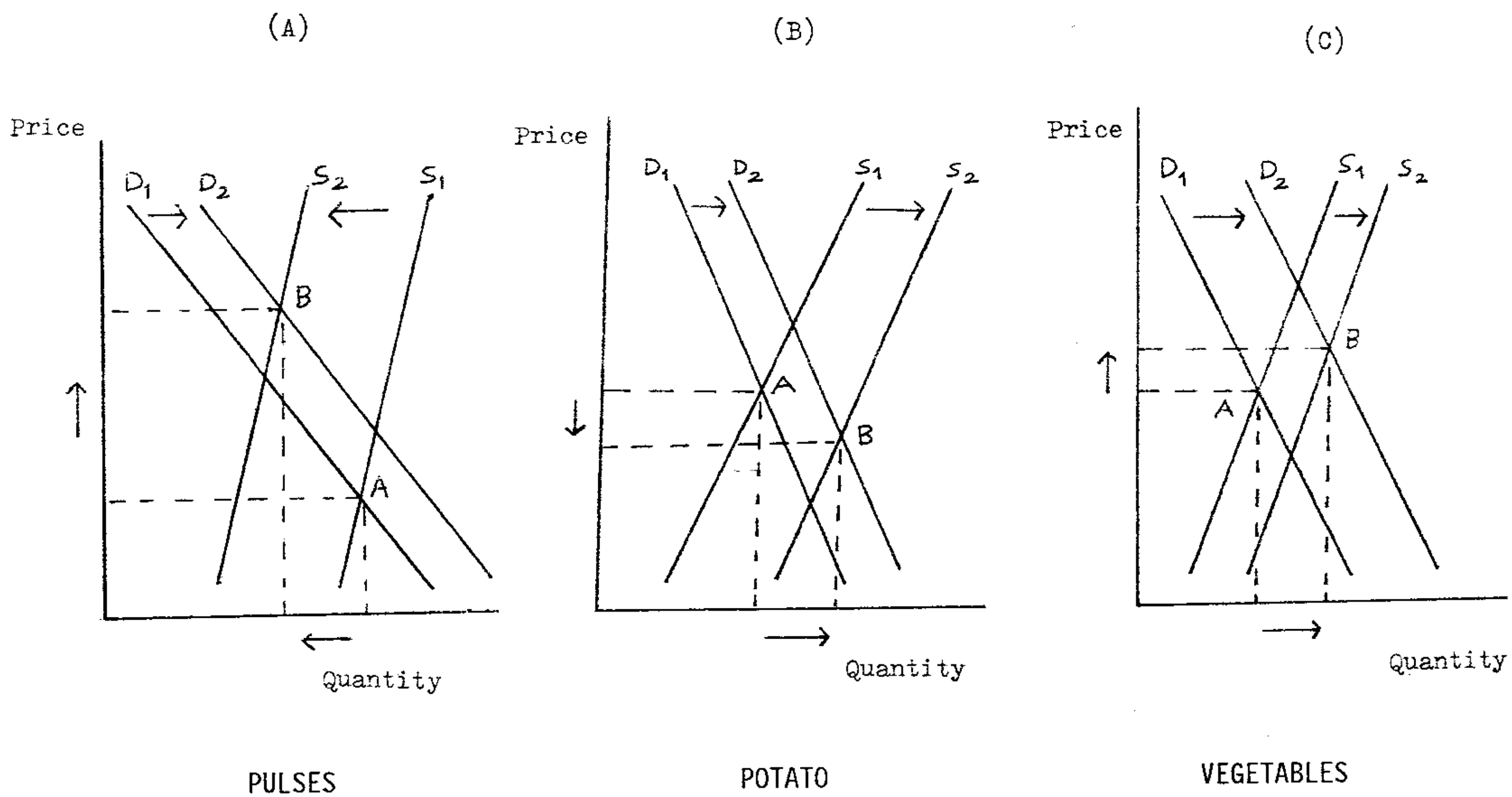
[49] Other scenarios that allow some international trade under quantitative restrictions can be easily accommodated in this framework.

[50] The shift in supply seems to have taken place as part of a general reallocation of area in favor of high-value crops; see the discussion in Chapter 2.

Figure 3.2--Interactions between supply response and price movements in commodity markets



4. TRADE POLICIES AND STRUCTURE OF AGRICULTURAL INCENTIVES

The policy regime regarding foreign trade and exchange rate management can affect the structure of incentives within agriculture as well as between agricultural and other sectors through direct and indirect effects on domestic price formation. The direct effect on prices arises from commodity-specific policies such as taxes, subsidies, or quantitative restrictions on export and import. This effect is measured by the proportional difference between the domestic price and the border price (the so-called import or export parity price) at the prevailing official exchange rate. The indirect effect of the trade-policy regime arises from its impact on exchange-rate determination. High import tariffs, for example, would discriminate exportables against importables by appreciating the exchange rate in relation to the equilibrium exchange rate that would have prevailed under a free-trade regime.[51] In order to assess the combined effect of trade policies, the border price therefore needs to be estimated at the equilibrium exchange rate in making the domestic-to-border price comparisons. Such a comparison could be taken as a measure of how, as a result of trade policies, the domestic price of a tradable commodity diverges from its true opportunity cost (that is, the border price that would have prevailed under an intervention-free regime).[52]

From its inception, Bangladesh has pursued a highly restrictive trade and exchange-rate regime characterized by high import tariffs and pervasive quantitative restrictions. The heavy taxation of imports provided a convenient source of generating government revenues while providing protection to import-competing domestic industries. The trade regime has been even more severely restrictive in the case of agricultural commodities. While exporting foodgrains is not permitted, the government has a monopoly on importing.[53] Most other agricultural commodities can be imported only under licensing schemes, while many are subject to an outright export ban. Even in the case of jute, the main export crop, severe restrictions have been imposed on its export in years of scarcity in order to maintain supplies to domestic jute mills.

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[51] Such a policy is also likely to discriminate exportables against nontradable domestic goods by lowering the relative price of the former.

[52] This is so because the free-trade equilibrium exchange rate can be taken to represent the "shadow" price of foreign exchange. It also needs to be assumed that the country is a price-taker in the international market. For a discussion of these issues, see Timmer 1986, Valdés and Siamwalla 1988, and Scandizzo and Bruce 1980.

[53] As a result of very recent policy changes, the import of foodgrains by private traders is now allowed in principle, while the ban on rice export has been partially lifted (for example, fine-quality rice).

These restrictive trade policies have been variously justified on grounds of protecting domestic producers from external competition, ensuring domestic availability of essential consumer items, and insulating the domestic markets from the instability in world commodity prices.

As a result of the structural adjustment measures carried out since the early 1980s, Bangladesh has now moved considerably toward a liberalized trade regime with flexible exchange-rate management. The policy reforms in this area have been generally aimed at lowering the tariff rates and freeing imports from quantitative restrictions. However, trade in agricultural commodities has continued to be highly restrictive, and the policy reforms did not affect these commodities up to the 1990/91 fiscal year.

The way trade policies affect producer incentives in agriculture would of course depend on the actual and potential trading status of the agricultural and agriculture-based commodities (see Table 3.8). Foodgrains, mostly wheat, have constituted the major agricultural import item and most of it has come as food aid. The import of rice has varied widely from year to year, and the recent trends in import and domestic production would suggest that the country is nearing self-sufficiency in rice. Besides wheat, in terms of the proportion of domestic supply met from imports, mustard seed, edible oils, sugar, and cotton are clearly importables. Some quantities of onion, chilli, lentils, and other pulses are also imported, especially in deficit years and lean seasons.[54] Tobacco is both imported and exported because of the differentiated product quality. There is virtually no foreign trade in potatoes, while some exports of vegetables and fruits have been taking place in recent years, mainly to cater to the needs of Bangladeshi communities living in the United Kingdom and the Arab Middle East. There is some potential for exporting spices in the future, provided domestic production can grow.

EQUILIBRIUM EXCHANGE RATE

The extent of distortions in the exchange rate caused by trade policies can be measured by comparing the actual official exchange rate with the estimated free-trade equilibrium exchange rate. The latter is an estimate of the exchange rate that would have prevailed in the absence of any trade interventions such as import tariffs, export taxes and quota restrictions. A variant of the so-called "elasticities approach" has been used to obtain an estimate of the equilibrium exchange rate, based on the estimates of implicit import tariff and export tax rates along with the estimates of (or assumptions regarding) the price elasticities of import demand and export supply. (See Appendix 1 for the algebraic framework used.) In the computations, the simplifying assumption has been made that both the above elasticities have a

[54] Bangladesh also imports citrus fruits every year and bananas occasionally.

value of unity in absolute terms. It is also assumed that the entire existing trade deficit in the current account is sustainable. In other words, the estimated equilibrium exchange rate for any year is consistent with the existing level of net capital inflow in that year.

The implicit rate of import tariff (t_m) and export tax (t_x) measure the extent of divergence between domestic and border prices created by trade policies. These are therefore a measure of protection generally provided to exports and import-substitutes and are different from the nominal duty rates because of the effect of quantitative trade restrictions (for evidence on this, see Bhuyan and Mahmud 1979). As such, these implicit tariff (tax) rates are better estimated by directly computing domestic-to-border price ratios for imports and exports, $(1 + t_m)$ and $(1 + t_x)$, respectively. The details of an exercise involving these computations are reported in a separate background paper of the present study.[55] The time-series estimates of implicit tariff (tax) rates and the equilibrium exchange rate are shown in Table 4.1. The equivalent tariff, which is estimated as $(1 - t_m)/(1 - t_x)$, shows the extent of discrimination against export vis-à-vis import substitutes. The misalignment of the official exchange rate compared with the estimated equilibrium rate, in percentage terms, is also shown in the table.

In the early 1970s, the implicit import tariff was very high along with a high degree of distortion in the official exchange rate. A large devaluation in the mid-1970s lowered the implicit tariff and the extent of exchange-rate misalignment. As a result of the liberalizing policy reforms initiated in the early 1980s, there has been a gradual decline in the implicit tariff, while the gap between the official and the equilibrium exchange rate has also been substantially narrowed. The implicit export subsidy $(-t_x)$, which was substantial in the 1970s, has come down to a low level following the exchange rate reforms.[56] As shown by the estimates of equivalent tariff, the trade-policy bias against export has been significantly high throughout most of the period under review, but this bias appears to have been reduced considerably toward the end of the 1980s. These average figures, of course, conceal very large variations in commodity-specific rates of protection, which are examined below for some agricultural commodities.

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[55] See Rahman 1993b. The methodology used is to compare domestic and border prices of as many import and export items as possible for a particular year, 1985/86, for which data are available. The implicit tariff (tax) rate is then computed as a trade-weighted average rate, where shares of import (export) categories represented by the individual items are used as weights. The time-series estimates are obtained by using the indices of domestic wholesale and border prices of imports and exports constructed for this purpose.

[56] The export subsidy has mostly been provided in an indirect way by providing exporters a limited access to the premium exchange rate in the secondary foreign exchange market. The high implicit export subsidy in 1984/85 is due to the abnormally high domestic price of raw jute in that year.

Table 4.1--Implicit tariffs and misalignment in exchange rate

Year	$1 + t_m$ (1)	$1 - t_x$ (2)	Equivalent Tariff (3)	Official Exchange Rate (4)	Equilibrium Exchange Rate (5)	Percent Misalignment (6)
1973/74	2.761	1.404	1.967	7.966	12.211	-34.758
1974/75	2.111	1.442	1.464	8.875	12.961	-31.523
1975/76	1.450	1.128	1.286	15.054	18.667	-19.355
1976/77	1.515	1.200	1.262	15.426	19.728	-21.808
1977/78	1.497	1.239	1.209	15.117	19.446	-22.264
1978/79	1.274	1.101	1.158	15.223	17.829	-14.617
1979/80	1.460	1.020	1.431	15.490	18.838	-17.774
1980/81	1.441	1.052	1.370	16.259	19.761	-17.723
1981/82	1.362	1.069	1.275	20.065	23.983	-16.336
1982/83	1.451	1.031	1.408	23.795	28.373	-16.134
1983/84	1.659	1.101	1.507	24.944	31.704	-21.324
1984/85	1.542	1.239	1.244	25.963	33.599	-22.725
1985/86	1.341	1.069	1.255	29.886	35.128	-14.922
1986/87	1.240	1.004	1.234	30.629	33.947	-9.773
1987/88	1.316	1.025	1.284	31.242	35.920	-13.022
1988/89	1.241	1.022	1.214	32.142	36.030	-10.790
1989/90	1.204	1.068	1.127	32.921	37.097	-11.256
1990/91	1.177	1.054	1.117	35.690	39.742	-10.196

Source: Authors' calculations according to methodology described in Appendix 1; see also S. H. Rahman, The Impact of Trade and Exchange Rate Policies on Economic Incentives in Bangladesh Agriculture, background paper of the IFPRI-BIDS Agricultural Diversification Study (Dhaka: Bangladesh Institute of Development Studies, 1993).

Notes: In column (1), t_m is implicit tariff on imports; in (2), t_x is implicit tax on exports; (3) = $(1 + t_m)/(1 - t_x)$; and (6) = (4) - (5) x 100.

TRENDS IN DOMESTIC-TO-BORDER PRICE RATIO

To assess the effect of trade and exchange-rate policies on agricultural incentives, domestic-to-border price comparisons have been made for a selected number of commodities at both the official and the estimated equilibrium exchange rate. The time-series estimates of these ratios can help explain how the trade policy environment may have changed over time for these commodities (Tables 4.2 and 4.3). The estimates of import parity prices are based on the assumption that imports compete with domestic production at the wholesale level;[57] however, for wheat and rapeseed the price comparisons are made at the farmgate level, since reliable time series of domestic wholesale prices are not available. (The domestic and border price series used for these estimates are given in Appendix 2, Tables A2.10-A2.13.) Later on, in the economic profitability exercise, a much larger number of commodities are

[57] In the case of rapeseed, at the millgate level.

Table 4.2--Trends in domestic-to-border price ratio of selected commodities at official exchange rate

Year	Rice[a] (Import Parity)	Rice[a] (Export Parity)	Wheat (Import Parity)	Lentil (Import Parity)	Potato (Import Parity)	Potato (Export Parity)	Rapeseed (Import Parity)	Sugar (Import Parity)
1974/75	1.04	1.50	1.42	...	1.30	9.02	2.16	1.06
1975/76	1.02	1.48	1.33	...	1.13	4.97	1.91	1.46
1976/77	0.71	0.95	0.92	...	0.90	3.25	1.40	1.77
1977/78	0.70	0.92	0.92	0.77	0.82	3.16	1.30	1.82
1978/79	0.75	0.99	0.87	0.82	0.81	3.78	1.32	1.25
1979/80	0.71	0.96	0.83	0.79	0.77	3.23	1.37	1.49
1980/81	0.76	1.07	0.88	0.88	0.68	2.79	1.34	1.80
1981/82	0.80	1.14	0.90	0.99	0.56	1.75	1.16	2.53
1982/83	0.95	1.41	0.92	1.06	0.57	1.63	1.13	2.86
1983/84	1.04	1.55	0.94	0.85	0.59	1.71	1.20	3.11
1984/85	1.04	1.65	0.99	0.82	0.65	2.07	1.45	3.60
1985/86	1.08	1.76	1.12	0.88	0.77	2.79	1.76	3.43
1986/87	0.98	1.51	1.11	1.14	0.73	2.17	1.85	2.85
1987/88	0.94	1.40	1.04	1.19	0.81	2.19	1.96	2.34
1988/89	0.88	1.30	1.02	1.12	0.81	2.09	1.85	2.22
1989/90	0.84	1.27	1.07	0.87	0.80	2.27	1.98	2.40

Source: Tables A2.11 and A2.13 in Appendix 2.

Notes: For wheat and rapeseed, the price parity is at the farmgate level, and for all other commodities, at the wholesale level. Trends are based on three-year moving averages of respective prices.

[a] Coarse-quality rice.

Table 4.3--Trends in domestic-to-border price ratio of selected commodities at equilibrium exchange rate

Year	Rice[a] (Import Parity)	Rice[a] (Export Parity)	Wheat (Import Parity)	Lentil (Import Parity)	Potato (Import Parity)	Potato (Export Parity)	Rapeseed (Import Parity)	Sugar (Import Parity)
1974/75	0.762	1.028	1.005	...	0.997	4.840	1.467	0.760
1975/76	0.799	1.094	1.001	...	0.911	3.199	1.403	1.122
1976/77	0.566	0.726	0.721	...	0.746	2.259	1.073	1.433
1977/78	0.570	0.726	0.740	0.629	0.684	2.222	1.018	1.503
1978/79	0.617	0.792	0.713	0.680	0.689	2.693	1.052	1.038
1979/80	0.595	0.785	0.690	0.660	0.660	2.439	1.115	1.249
1980/81	0.635	0.871	0.721	0.735	0.579	2.118	1.088	1.506
1981/82	0.673	0.935	0.744	0.837	0.478	1.376	0.948	2.142
1982/83	0.793	1.127	0.746	0.881	0.477	1.250	0.905	2.416
1983/84	0.847	1.203	0.747	0.687	0.488	1.272	0.932	2.585
1984/85	0.853	1.277	0.788	0.669	0.543	1.537	1.131	3.021
1985/86	0.927	1.440	0.931	0.746	0.672	2.174	1.425	2.995
1986/87	0.868	1.297	0.963	1.010	0.653	1.787	1.572	2.541
1987/88	0.847	1.219	0.915	1.070	0.735	1.853	1.700	2.103
1988/89	0.787	1.128	0.897	0.999	0.731	1.773	1.594	1.991
1989/90	0.763	1.114	0.952	0.781	0.732	1.942	1.728	2.167

Source: Tables A2.12 and A2.13 in Appendix 2.

Note: For wheat and rapeseed, the price parity is at the farmgate level, and for all other commodities, at the wholesale level. Trends are based on three-year moving averages of respective prices.

[a] Coarse-quality rice.

covered in border price comparisons for 1990/91.[58] (See Appendix 2, Table A2.14, and Mahmud 1993b for details of these estimates.)

These estimates of domestic-to-border price ratios should be interpreted, keeping in view the many conceptual and data problems involved in such price comparisons. In most cases, the average import and export prices as recorded in the country's trade statistics cannot be used to represent competitive market prices.[59] It is therefore necessary to make independent estimates of border prices, based on internationally quoted prices along with assumptions regarding freight costs. In the case of potential exportables or importables, the estimates of border prices would also involve assumptions regarding the ports of origin or destination. There is an even more serious problem of quality comparison between the domestically produced and the internationally traded commodities. This study has relied extensively on interviews with traders as well as findings from market surveys in identifying products of similar quality (or in making quality adjustments to prices). (For details, see Rahman 1993b.)

Rice

Given the predominance of rice in crop agriculture, the impact of trade policy on agricultural incentives would be largely determined by what happens in the case of rice. The border price comparison for rice is for coarse-quality rice, which accounts for most of the rice produced in the country.[60] At the official exchange rate, the domestic rice price has mostly remained within the band of import and export parity prices. This implies that in most years there has not been any positive or negative protection for rice through import or export taxation or trade restrictions. The trade policy, nevertheless, can be held responsible for lowering the domestic rice price through public import of foodgrains, mostly under food aid. The effect of such imports on domestic rice price is equivalent to an import subsidy as measured by the nominal rate of protection (NRP) at the import parity price. However, the meaning of an estimate of NRP in such a situation is not

[58] It should be noted, however, that the marketing (and processing) margins used here for estimating the border parity prices are in "financial" terms, while those used in the economic profitability exercise are converted to "economic" terms. The estimates of these margins for 1990/91 are based on a survey of agricultural marketing undertaken for the present study; the estimates for earlier years are derived by using appropriate price deflators for various cost components; for details, see Rahman (1993b).

[59] For example, in the case of imports financed by foreign grants, the import prices are used only for accounting purposes, and these often vary widely from international market prices.

[60] The average of the price of 5 percent broken and 25 percent broken Thai rice is used to represent the price of coarse-quality rice in Bangladesh. Discussion with traders suggested that the coarse rice produced in the country is markedly superior to the internationally traded 25 percent broken Thai variety. Also, a recent market survey has shown that domestic coarse rice mainly consists of about 15 percent broken. However, there is no internationally quoted price available for 15 percent broken Thai rice.

straightforward, as can be seen from the following diagrammatic exposition.

In Figure 4.1, the price impact of government intervention through subsidized import of rice is measured by comparing the actual domestic price, P_d, with the price that would have prevailed in an intervention-free trade regime. This latter price would be either the price determined entirely by domestic supply and demand, $\hat{P}_d$, (as in Figure 4.1 A) or the import parity price, P_m, (as in Figure 4.1 B), whichever is lower.[61] The extent of the price effect can therefore be lower than what would be indicated by the NRP estimate based on the import parity price; but such an estimate would still indicate the upper bound of negative protection resulting from direct trade policies.[62] The estimates presented here suggest that there might have been substantial negative protection for rice only in the late 1970s, which was eliminated in the later years.

When the equilibrium exchange rate is considered, however, there appears to have been negative protection for rice in relation to the import parity price throughout the entire period under review. Even at the export parity price, there was substantial negative protection (about 25 to 30 percent) during the late 1970s. The domestic price of rice has therefore remained lower, at times by very substantial margins, compared with its opportunity cost in border price terms (which, in a rice-import regime, would be represented by the import parity price at the shadow or equilibrium exchange rate). However, all this is now changing as the country approaches self-sufficiency in rice, while the implicit subsidy on wheat import is also virtually eliminated. In the evolving scenario, as a result, the trade policies have increasingly become neutral to domestic rice price determination.

<u>Nonrice crops</u>

The trends in the domestic-to-border price ratio for wheat are very similar to those for rice. In most years, however, the extent of divergence between the domestic price and the import parity price has been less for wheat than for rice. In fact, in recent years, the domestic wheat market appears to have been somewhat protected at the official exchange rate, although not at the equilibrium rate.

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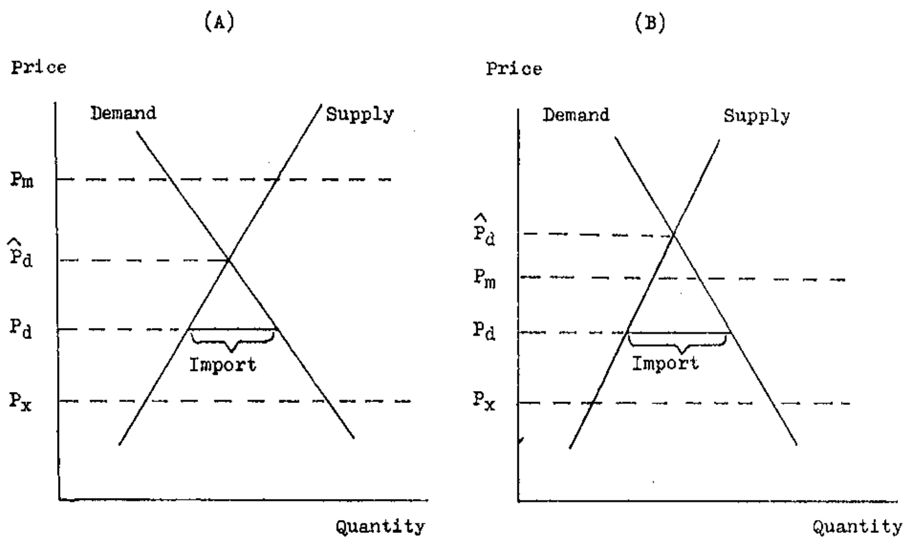
[61] The effect of an implicit subsidy on wheat import also needs to be considered here. In the absence of such a subsidy, a higher wheat price would have led to an outward shift in the rice demand curve, thus increasing the equilibrium price of rice $\hat{P}_d$. In the diagram, this effect may be incorporated by assuming that wheat imports, in rice equivalent, are included in the quantity of import shown.

[62] This ambiguity surrounding the NRP estimate arises essentially from the divergence between the export and import parity prices, often abstracted away in the literature. The standard diagrammatic method of measuring welfare losses of trade intervention by the so-called triangles of deadweight loss is not directly applicable. See, for example, Timmer 1986 for an elaboration of this method, and Rahman and Mahmud 1988 for an application in the context of public foodgrains import in Bangladesh.

Figure 4.1--Implication of import and export parity prices in domestic market



Note: P_d is actual domestic price, $\hat{P}_d$ is equilibrium price determined by domestic supply and demand, P_m is import parity price, and P_x is export parity price.

The nominal rate of protection for sugar and mustard seed (represented by rapeseed) has been consistently positive and at times very high.[63] Even at the equilibrium exchange rate, these two items appear to have been heavily protected (with the exception of rapeseed in the early 1980s). Among crops and crop-based products, these are the two major items found to enjoy substantial protection after taking into account the direct and indirect effects of trade policies. As will be discussed in the profitability analysis that follows, much of the protection to sugar is absorbed by the highly inefficient public refineries that procure sugarcane at administered prices. But protection to sugarcane at the farm-level is also provided through higher prices of gur (raw sugar), which is an inferior substitute for imported white sugar.[64] Lentils appear to be somewhat protected in recent years, but only at the official exchange rate. Previously self-sufficient in pulses, the country became an importer during the early 1990s. There is virtually no foreign trade in potatoes, with imports limited to seed

[63] Mustard is also protected at the farm level through very high protection provided to the edible oil industry.

[64] The major share of the sugarcane produced in the country is used for gur-making by traditional methods.

potatoes only.[65] The domestic price of potatoes has mostly remained within the band of import and export parity prices at both the official and equilibrium exchange rates, implying that the effect of trade policy has been neutral.

ADJUSTING TO CHANGING WORLD PRICES

The movements in the domestic-to-border price ratio, estimated at the equilibrium exchange rate, can be expected to depict the relative movements of prices in real terms in the domestic and world markets.[66] An analysis of these underlying price trends would help explain how far domestic price movements have been in conformity with the changing comparative advantage as signaled by changes in world prices. The trends in the border prices in real terms (that is, deflated by the world price index) can be seen from Table 4.4. While international agricultural commodity prices generally declined in the 1970s and 1980s, this decline was quite uneven across commodities. Chapter 3 discussed the trends in deflated domestic harvest prices, which show large variations over time but without any uniform pattern across crops or crop groups. The trends in deflated wholesale prices are not presented here; they are very similar to those in harvest prices (see Tables 3.10 and 3.11 and Figure 3.1).

It can be seen that the international price of rice fell dramatically in real terms in the mid-1970s and again during the first half of the 1980s. The domestic rice market (and the market for wheat) has been largely insulated from the international market because of trade controls and also because the domestic prices have remained mostly *within* the band of export and import parity prices.[67] The domestic foodgrain price did, however, fall dramatically following the food-crisis years of the early 1970s, but this was mainly due to the large infusion of food aid. Thereafter, the steady increase in the domestic-to-border price ratio of rice up to the mid-1980s was almost entirely due to the sharp fall in world prices, which brought the domestic price to the level of the world price. Since the mid-1980s, there has been some moderate decline in the domestic price of rice in real terms, while the world rice price recovered to some extent (Table 4.4). This has again caused the domestic rice price to move downward within the band of the import and export parity prices. While there is some concern among

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[65] In the mid-1970s, some small quantities of potatoes were imported by the government. On the other hand, a very small quantity has been exported under the government's initiative in the recent past.

[66] This is so, since the estimated equilibrium exchange rate can be taken to roughly depict the relative rates of domestic and international inflation.

[67] Similarly, the exchange-rate policy has had no effect on domestic foodgrain prices. Indirectly, however, the exchange rate and world prices do matter, since these affect the size of food subsidy and the cost of food stocks.

Table 4.4--Trends in estimated border prices of selected commodities in 1985 constant dollars (three-year moving averages)

Year[a]	Rice	Wheat	Lentil	Potato	Rapeseed	Sugar	Jute
			(US$/metric ton)[b]				
1974/75	552	283	...	193	523	778	496
1975/76	402	226	639	166	442	476	479
1976/77	384	191	543	138	402	305	425
1977/78	377	188	564	125	387	251	435
1978/79	389	193	567	125	348	376	406
1979/80	394	206	658	150	333	434	352
1980/81	374	206	637	166	322	424	292
1981/82	332	201	539	169	328	280	273
1982/83	273	190	446	155	339	194	304
1983/84	256	179	483	143	337	160	456
1984/85	224	158	509	131	297	135	467
1985/86	194	133	493	110	228	131	416
1986/87	192	118	371	109	187	151	259
1987/88	210	126	361	114	172	180	247
1988/89	217	129	380	120	175	206	265
1989/90	213	121	444	118	158	195	267

Source: Table A2.10 in Appendix 2.

Note: Trends are estimated by deflating import (export) prices by world inflation index in U.S. dollar terms (1985=100).

[a] The central year of the moving average.

[b] For rice, wheat, lentil, potato, rapeseed, and sugar, the dollar figure is the c.&f. import price; for jute, it is the f.o.b. export price.

policymakers about the resulting effect on the profitability of rice production, these price movements should be interpreted as a reflection of a changing comparative advantage in Bangladesh agriculture.[68] As the country approaches self-sufficiency in rice while the domestic wheat price is maintained near its import parity level, the decline in the real rice price cannot be blamed on a "cheap food policy" pursued by the government. As discussed earlier, this contrasts with the experience during the earlier periods, especially during the late 1970s and early 1980s.

The high protection rates that have emerged in the case of oilseeds and sugar largely reflect the inability of the domestic prices to adjust to changing world prices. As will be seen later, this has important implications for the structure of comparative advantage vis-à-vis private profitability in crop agriculture. The world price of oilseeds (represented by rapeseed) has secularly declined, the decline being most dramatic in the 1980s (when prices were nearly halved). The domestic

[68] Much will, however, depend on whether the momentum in growth of rice production can be maintained.

price, on the other hand, fell sharply in the 1970s, but only modestly in the 1980s. As a result, the nominal protection rate has been rapidly increasing since the early 1980s. Although the world price of sugar has been extremely volatile, there has been a sharp declining trend since the early 1970s, with some recovery only in the late 1980s. During this time, the country has moved from a regime of relatively modest protection and near self-sufficiency in sugar to one of very high protection with large imports.

The decline in the world prices of both pulses (lentils) and potatoes in real terms has been much more modest than that of other agricultural commodities. As discussed earlier, the domestic prices of pulses have increased considerably over the years due to declining domestic production, and this is reflected in the increasing trends in the domestic-to-border price ratio. As the country now moves from being self-sufficient to an importer of pulses, the world price has become relevant in deciding the country's comparative advantage in producing pulses. The domestic price of potatoes declined very rapidly up to the early 1980s due to high production growth, causing the domestic price to move away from the import parity to the export parity level. But with the decline in production growth since then, the trends have been reversed. It may be noted that due to high freight costs, the estimated band between the import parity and the export parity prices is relatively wide for potatoes.

The world price of jute, the main export crop of Bangladesh, has been nearly halved in real terms in two decades from the level of the early 1970s. There have been, however, very large "cyclical" fluctuations in the world price, which are reflected in the domestic harvest price of jute (see Figure 3.1). It is worth noting that, unlike the world price, the domestic price of jute in real terms has not secularly declined to any significant extent, if at all. This is largely explained by the withdrawal of the export tax on jute in the late 1970s and the depreciation of the exchange rate in the 1980s. Thus, the reduced policy discrimination against jute has helped in maintaining producer incentives over the long run in the face of deteriorating competitiveness of jute in the world market.

5. COMPARATIVE ADVANTAGE IN CROP AGRICULTURE

PRIVATE VERSUS ECONOMIC PROFITABILITY: DATA AND METHODOLOGY

Economic Profitability Criteria

Private profitability, which is the basis for farmers' decisions, is based on calculation on prices farmers actually receive or pay. These prices may diverge from the society's opportunity costs of inputs and outputs because of many distortions in the product and factor markets, such as those arising from trade restrictions, government taxes or subsidies, monopoly elements in marketing, surplus labor conditions, and segmentation in the capital market. In Chapter 4, the effects of tariffs and trade policies on price formation in the domestic markets for agricultural products have already been discussed. The results of a profitability exercise designed to assess the pattern of comparative advantage vis-à-vis private profitability in crop production are reported here (on these issues, see Timmer, Falcon, and Pearson 1983, 139-147).

In this study, economic profitability of crops, as distinct from private profitability, is estimated in terms of "net economic returns" per unit of cropped land (vis-à-vis net private returns). The methodology followed is essentially an annualized version of the Little-Mirrlees method of social cost-benefit analysis in which all costs and outputs are valued at their opportunity costs at border prices (although expressed in domestic currency at the official exchange rate).[69] But, unlike in social cost-benefit analysis, no social weights are applied regarding consumption, saving, and income distribution.[70] The capital costs (especially the costs of irrigation investments) are included as the annual rental charge so as to cover capital recovery at the social discount rate (that is, the accounting rate of interest). Land rents are not, however, included as costs, so the profitability estimates represent net returns to land (and managerial skills). For assessing profitability, the crop production activities are distinguished by the

[69] See Little and Mirrlees 1974, 145. It should not matter for the ranking of economic profitability of crops whether the "shadow" exchange rate or the official rate is used for converting foreign prices into domestic currency equivalents, since all valuations are, in principle, in terms of foreign exchange, say, in dollars. However, in comparing the private and the economic profitability of a crop, using the shadow exchange rate would capture the full extent of the divergence between the two arising from all price distortions, including any misalignment in the exchange rate.

[70] That is why "economic" rather than "social" profitability is used here, as the latter term has welfare connotations extending beyond the concept of opportunity cost.

irrigation-seed technology and are so chosen as to cover important areas of choice regarding crop diversification.

The estimation of net economic returns per unit of cropland is one way of looking at comparative advantage in terms of efficiency of resource use and land allocation for producing alternative crops or crop mixes. However, in order to meaningfully interpret these estimates as an indicator of comparative advantage, it is necessary to know the nature and scope of competition (or complementarity) in the choice of crops. The evidence on alternative cropping patterns according to different land types was discussed in an earlier chapter. Although most nonrice crops compete for land in the dry boro season, there is not always a one-to-one substitution between two crops. In some cropping patterns, the substitution of one dry-season crop for another may also entail changes in the choice of crops in other seasons (because of overlapping crop-growing seasons and other agroclimatic factors). In such a case, the appropriate profitability comparisons would be among the alternative year-round cropping patterns (rather than among individual seasonal crops). In the more obvious case, the profitability of a perennial crop like sugarcane has to be, of course, compared with that of an annual sequence of seasonal crops that can be grown on similar land.

An ideal cropping pattern can be defined in a *static* sense involving mainly a reallocation of land and variable inputs, with a given level of land and water resource development and the existing state of technological knowledge. In a *dynamic* context, however, the ideal crop mix would depend on the pattern of agricultural investments and the technological developments that are envisaged. In principle, therefore, determining an ideal product mix and setting priorities in agricultural investments and research are interrelated exercises.[71] The profitability indicators presented here incorporate both the static and dynamic aspects, although in a limited way. As mentioned above, the crop activities are modeled according to their irrigation status, which permits assessment of relative profitability under given irrigation conditions (namely, nonirrigated, and irrigated by traditional methods and by modern methods). Moreover, comparing the profitability of irrigated crops (or crop mixes) with that of the unirrigated ones that are replaced can indicate whether the underlying investment in irrigation is economically profitable. (This is so because the cost estimates cover the annual capital recovery at the social rate of discount, which represents the opportunity cost of capital.) Of the two modes of irrigation considered here, traditional irrigation methods involve mostly current labor inputs with very little fixed investments, while under modern irrigation the costs of irrigation by power pumps and shallow and deep tubewells have been taken into consideration (as weighted average). However, no crop activities with investments in large-scale irrigation and flood control projects have been modeled

[71] Little and Mirrlees (1974, 112) discuss the implication of this for designing irrigation projects.

here, so the present set of results cannot indicate the profitability of such investments.[72] As for the potential effect of technological innovations on profitability, some estimates are presented later in this chapter, based on "synthetic" crop activities incorporating changes in production techniques.

An important consideration in assessing the relative profitability of irrigated crops arises from the wide variation in water requirements among crops, so the area that can be irrigated from an installed facility would depend on the choice of crops to be grown. Paddy cultivation, which needs continuous irrigation and flooding, is much more demanding on water compared with most other crops. Farm-level research shows that for every hectare of land irrigated for HYV boro paddy, 3 to 4 hectares of land could be irrigated for growing modern varieties of wheat, potatoes, and winter vegetables and 6 to 7 hectares for mustard and pulses (to meet the recommended water requirements under average soil conditions).[73] Since investments in fixed capital are likely to be the effective constraint to the expansion of area under irrigated crops, it is the profitability per unit of water use, rather than per hectare of irrigated land, that would more often be the appropriate criterion for ranking crops under irrigated conditions. An example will make this clear. Let us suppose that Crop 1 is a non-irrigated crop that can be replaced by either Crop 2 or Crop 3 with the provision of irrigation and that the net returns per hectare from these crops are r_1, r_2, and r_3, respectively. However, Crop 3 is less irrigation-intensive than Crop 2, so, with the same amount of water, the area that can be irrigated for Crop 3 is, say, λ times larger than that for Crop 2. In this case, the appropriate comparison of net economic returns for the ranking of the irrigated crops would be $(r_2 - r_1)$ for Crop 2 vis-à-vis $\lambda(r_3 - r_1)$ for Crop 3. This is also the criterion of crop choice that would maximize the economic profitability of a given irrigation investment (for example, a tubewell of a certain capacity).[74]

The above consideration can also be a source of conflict between what is profitable for the individual farmer and for the society regarding water management and crop choice. Opting for a more water-

[72] Admittedly, the method of annualized net economic returns, as followed here, cannot be a substitute for a full-fledged cost-benefit analysis of investment projects, particularly when there is likely to be a time-lag involved in reaching the "full development" stage, as in the case of large-scale water development projects. The estimates of relative profitability of crops presented here may therefore be considered as complementary to the exercises in economic analysis of agricultural investment projects. See, for example, Master Plan Organisation 1987a for this latter type of exercise undertaken in connection with the preparation of the National Water Plan.

[73] These estimates are from the unpublished research findings of the Bangladesh Agricultural Research Council.

[74] If, however, for a particular locality, the irrigation investments already made (or the investment prospects) are such that the entire farmland could be brought under irrigation irrespective of the choice of crops, the objective of crop choice would be again maximization of returns per hectare.

intensive crop would mean that a smaller number of farms can get their plots irrigated from a given irrigation capacity. If this crop happens to have higher profitability per hectare, the beneficiary farmers would prefer this crop to a less water-intensive one, although the latter might yield higher returns to the irrigation investment by distributing the benefits among a larger number of farmers. Much would, however, depend on the system of ownership and management of the irrigation facility.

It may be noted that in this study, the preference has been to estimate net economic returns per hectare rather than the more familiar domestic resource cost (DRC) as a measure of comparative advantage in crop production. There are admittedly many conceptual and empirical problems with any such measure of comparative advantage (see, for example, Scandizzo and Bruce 1980 for a review of these methodologies). Unlike the present profitability exercise, the DRC method would involve the estimation of the rental value of land (which is a primary nontraded factor). However, because of the complex nature of the land tenurial institutions and the special value often placed on landownership, neither the rental rates nor the land prices are necessarily related to the marginal productivity of land. Compared with the DRC method, the estimation of net economic return per unit of land is also simpler and less arbitrary in that one does not have to worry about the distinction between the items representing domestic and foreign resources (to be put in the numerator and the denominator of the DRC coefficient). More important, the relative economic value of the crops considered here is in the nature of mutually exclusive projects so far as land allocation among competing crops is concerned. As such, the net benefit per unit of land is likely to be a more appropriate guide for the *ranking* of crops, compared with that per unit (or taka) of the domestic resources (which is what the inverse of the DRC coefficient essentially depicts) (see Scandizzo and Bruce 1980). However, the estimation of DRC can be a convenient method of *generally* assessing the comparative advantage of a single dominant crop, such as paddy in many Asian countries, by indicating the economic profitability of keeping resources in its production (see, for example, Anderson and Ahn 1984).

Border Price and Output Valuation

The derivation of appropriate international reference prices for comparison with the domestic prices was discussed in the previous chapter (see also Appendix 2, Table A2.14, and Mahmud 1993b). Here some additional points are noted regarding the use of these international border prices in the economic profitability exercise. Given the year-to-year fluctuations in the international commodity prices, a set of "normalized" prices needs to be derived for the financial year 1990/91, which is the reference period for the profitability estimates. For this, the three-year average of c.i.f. or f.o.b. prices in 1990/91 constant dollar terms have been taken.[75] For some crops, alternative estimates of economic profitability have also been derived by using the projected world prices for 1995 in constant 1990/91 dollars.[76]

The choice of appropriate economic (that is, accounting) prices for output valuation should depend in principle on the assumption regarding whether additional output will be used for export or import-substitution or domestic consumption. In practice, because of trade restrictions and lack of market integration, it is not often easy to make a clear distinction in this respect, so it may be worthwhile to derive profitability estimates under alternative assumptions (as done in this study). For some crops, it may also be useful to assess their potential comparative advantage on the basis of prospective changes in their tradability status. Among the crops for which the import parity price is used as the basis for output valuation (directly or via processed products) are wheat, oilseeds, pulses, chilli, onion, sugarcane, and cotton. On the other hand, jute is clearly an export item, while vegetables (as well as tobacco) have only a limited access to the export market, so additional production is perhaps more likely to increase domestic consumption than raise exports. Nevertheless, the export potential of vegetables deserves careful consideration. Potatoes are not presently traded, but their economic profitability for export may also be worth looking at.

As for rice, it was noted earlier that the country seems to be on the verge of attaining self-sufficiency and that the domestic price is well inside the band of export and import parity prices. If the parity prices were not wide apart (or if there were likely to be a frequent switch from export to import and vice versa), one could take the average of the two figures as a practical method of valuing domestic production. Instead, in one scenario, rice is treated as nontraded and a variant of the principle that the valuation of a nontraded consumer good should be based on the marginal social benefit derived from its additional consumption is applied (expressed in economic price terms) (see Little and Mirrlees 1974, 188-191, 220-221). If it is assumed that the consumption of rice is socially so valued as to warrant a free-trade policy for rice (as is the recently adopted official policy in respect of rice import), the domestic price would be the same as the export or the import parity price in the event of such trade actually taking place. The domestic price can then be taken to represent both the marginal social benefit (according to the criterion of consumers' willingness to pay) and the economic price in foreign exchange equivalent. Thus, by comparison with the parity prices, the domestic price

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[75] The annual c.i.f. or f.o.b. prices of 1989, 1990, and 1991 are converted to constant 1990 dollars by using the world inflation index discussed earlier (see also Appendix 2, Table A2.13. An inflation factor for six months has been applied to adjust for the fiscal year.

[76] This has been done on the basis of commodity price projections at 1985 constant dollars (as of mid-1991) made by the World Bank's International Trade Division. The projected percentage price changes between 1990 and 1995 have been applied here to the estimates of 1990/91 world prices at current dollars. Ocean freight rates are assumed to remain unchanged at their current level.

lying in between can also be taken as the appropriate price for economic valuation (since the change in the domestic price would represent the change in the marginal social benefit).[77] Compared with the "averaging method," this would allow the economic price to vary with the anticipated demand-supply situation during a phase of transition from import to export or vice versa, as shown in Figure 5.1. Incidentally, however, the average of the estimated import and export parity prices for rice is very close to the domestic price used in the profitability estimates for 1990/91 (see Appendix 2, Table A2.14). For the nonrice crops as well, the domestic price has been taken as the basis for economic valuation in the nontraded situation, in order to make the profitability estimates comparable to those for rice.[78]

The use of border prices for economic valuation also involves the problem of appropriate quality comparisons between traded commodities and their domestic substitutes. As discussed in the previous chapter, the border price of rice as estimated in this study corresponds to the coarse-quality rice produced in the country. In economic profitability estimation, this price is used for all boro rice varieties. The economic prices of aman and aus varieties are derived by comparing the five-year averages of actual harvest prices of boro, aus, and aman rice. Similarly, the import parity prices of lentil and mustard oil are used for estimating the economic prices for other pulses and edible oils. Again, the economic price for gur (raw sugar) is derived from that of sugar by applying the ratio of actual domestic prices (which can be taken to represent the rate of consumer substitution between gur and sugar).

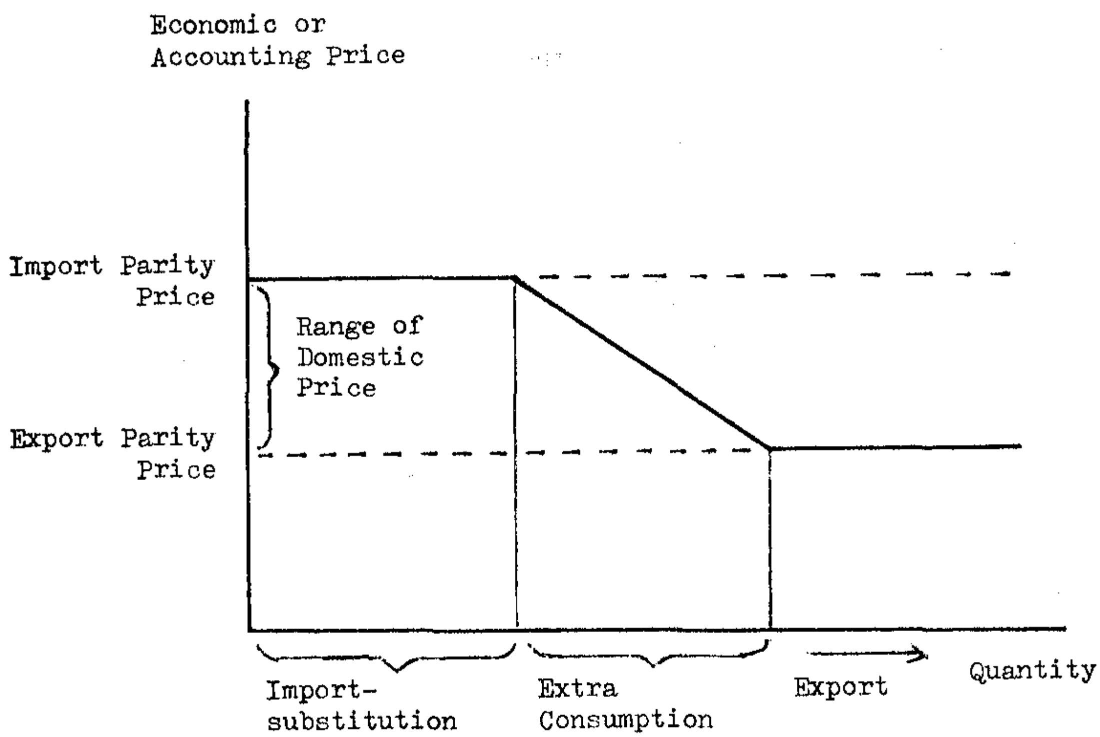
Marketing and Processing Margins

In order to derive the economic price of agricultural output at the farmgate level, the border prices need to be appropriately adjusted by the "economic" costs of marketing and processing. These economic costs, in turn, are derived from the estimated financial costs by applying the economic prices of factor inputs in the marketing and processing activities. The adjustment of border prices for marketing margins depends on assumptions regarding the location of producing areas and (in the case of import substitutes) the marketing stage at which domestic production competes with imports (for a discussion of this, see Timmer, Falcon, and Pearson 1983, 164-173). In the present study, the wholesale

[77] If one ignores the income distributional effect caused by the price changes, the accounting price of a nontraded consumer good according to the Little-Mirrlees method would be given by its prevailing domestic price, converted to border price terms by some consumption conversion factor. The methodology followed here is equivalent to using a conversion factor of unity. See Little and Mirrlees 1974, 219-221.

[78] Since the economic valuation is determined at the wholesale level, the economic price at the farmgate level would still vary from the prevailing domestic price (because of the difference between the economic and financial costs of marketing); see the discussion in the following section.

Figure 5.1--Variation of economic price during import-export transition



market in Dhaka is taken as the appropriate marketing stage for this purpose. Given the fact that the agricultural marketing system in the country is centered around Dhaka, this seems to be the most representative scenario regarding the substitution between imported and domestically produced commodities.[79] Most of the exports are also assumed to be routed through the Dhaka market; and in the case of nontraded commodities, the economic pricing is based on the assumption that the additional production will be marketed in Dhaka.

The marketing and processing costs, in financial terms, are estimated from an extensive survey conducted for the present study (Rahman 1993a). The survey traces the marketing channels of a large number of agricultural commodities starting from primary markets to the Dhaka wholesale market (and between the wholesale markets and the international ports). The locations of the producing areas covered are fairly widespread throughout the country (except when production is

[79] Even when some imports are marketed in an interior region, these may be competing with domestically produced commodities that are routed through Dhaka from a surplus-producing region to this region. In this case also, the above pricing principle will be valid.

regionally concentrated). The data from the survey, which has a reference period of one year (1990/91), permit the estimation of unit marketing and processing margins over harvest prices; these average margins are so estimated as to incorporate the effect of the seasonal variation in wholesale prices and the timing of sales in the wholesale market.[80] To convert the estimated "financial" margins into "economic" costs, these are broken down into elements of costs (for example, labor, transport, and rental value of fixed capital, including machinery and buildings) and pure marketing profits; economic pricing is then applied to each of these elements. The pure marketing profits represent returns to entrepreneurship and risk-bearing, and cover the cost of working capital (which in turn, would depend on the value of goods in the pipeline and the average turnover period). In the "economic" valuation of marketing costs, the pure profits are replaced by an imputed cost, which in principle covers the social opportunity cost of working capital (as well as a premium for entrepreneurship and social risks).[81] It may be noted that the actual marketing profits are often found to be quite high, presumably because of high private risks and (or) market imperfections. The estimated economic costs of marketing can therefore be substantially lower than those in financial terms (see Appendix 2, Table A2.14, and Mahmud 1993b).[82]

The economic prices used for output valuation, as estimated above, correspond to the marketing channels and producing locations that are covered by our marketing survey. On the other hand, the farmgate prices used in the financial profitability estimates for 1990/91 represent the "normalized" price for that year as well as the *average* for the country as a whole.[83] The two sets of estimates are not therefore exactly comparable in terms of the location of the producing areas (although both correspond to "normalized" domestic and border prices, respectively, for 1990-91). There are very large variations in harvest prices across regions and from one year to another. The estimated configurations of the harvest and wholesale prices (along with the associated marketing margins) in financial terms for 1990/91 should therefore be used only as a rough guide to how financial and economic prices compare around that year.[84]

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[80] To ensure this, the margins are in principle trade-volume-weighted in respect of the length of the turnover period subsequent to the harvest sales.

[81] In order to estimate the cost of working capital, an accounting rate of interest is applied to the "economic" valuation of the product in the pipeline, along with the assumption regarding the average length of the turnover period.

[82] Part of the discrepancy also arises from the economic pricing of labor and other inputs in the marketing and processing activities.

[83] These estimates of harvest prices are based on the trend projections of official harvest price series as well as information gathered by two IFPRI-BIDS surveys, one on agricultural costs and returns and the other on agricultural marketing; see Zohir 1993b and Rahman 1993a.

[84] See Appendix 2, Table A2.14. The wholesale prices are in respect of the Dhaka wholesale market and are also "normalized" to abstract from the effect of annual fluctuations.

Production Coefficients

The estimates of crop yields and production input coefficients used in the profitability exercise are primarily based on the findings from a survey on costs and returns of crop production undertaken for the present study (Zohir 1993c). This was a fairly large-scale survey designed to cover the different agro-ecological zones of the country with special emphasis on generating information on the relatively minor crops usually missed by most farm surveys. Information on production costs and yields is also available from a number of other recent surveys, particularly in respect of the major crops. An attempt has been made here to reconcile the estimates available from these various studies, including the survey done for this study, to identify a "representative" set of estimates of crop production activities.[85] These estimates are taken as the "average" for the respective crop activities as may be distinguished by irrigation technology and (or) seed variety.[86]

There are admittedly large variations in crop yields and input requirements depending on the suitability of the agroclimatic environment for producing particular crops. The production technology may also vary among farms of different sizes. Ideally, the competitiveness among crops in land allocation can be determined only by looking at relative profitability in respect of a *given* land-type and production environment. The estimates of "average" profitability, as presented here, should therefore be treated with some degree of caution in assessing the competitiveness of crops. Fortunately, some of the findings of the present study would appear to be robust enough to convey meaning in spite of these conceptual and data limitations.

Private profitability is estimated on the basis of full-costing of inputs; that is, both cash-purchased and family-owned inputs are valued at market prices. In particular, the prevailing market wage rates are used for valuing both family and hired labor.[87] For economic profitability estimation the inputs are, in principle, valued in terms of the output foregone in their alternative uses, converted into border price terms (Mahmud 1993b). The social opportunity costs of both family and hired labor are assumed to be the same, but labor used in the slack-season activities is taken to have an opportunity cost significantly lower than market wages.[88] As regards chemical fertilizers, the export

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[85] These reconciling adjustments have been made only in respect of the major crops; for details, see Zohir 1993c.

[86] The major features of these activities are shown in Appendix 2, Table A2.15; for details, see Mahmud 1993b.

[87] Private profitability estimates based on only cash costs are reported in Zohir 1993c. These are appropriate only if the opportunity costs of family-owned inputs, including family labor, can be assumed to be near zero.

[88] The estimates of labor inputs in person-days are available by activity types from the survey data.

parity price at the farmgate level is used for urea, while the import parity price is used for other types of fertilizers.[89] The economic costs of irrigation are estimated by imputing the rental value of machinery and adding to it the current operating costs, all converted into border price terms. The estimate of irrigation cost per hectare represents a "weighted" average of costs in respect of various modes of mechanized irrigation (that is, pumps and tubewells). The estimate varies among different irrigated crops so as to reflect the varying water-intensities of these crops as discussed earlier.[90]

ESTIMATES OF PROFITABILITY

The estimates of economic and private returns per hectare for rice and nonrice crops are presented in Tables 5.1 and 5.2, respectively. While for some crops the economic profitability estimates correspond to alternative assumptions regarding their tradability status, private profitability is estimated using only a single set of "normalized" farmgate prices for 1990/91. Economic profitability at the projected 1995 real prices, whenever estimated, are shown by the figures in parentheses (Table 5.2).

Profitability of Rice Crops

For rice, the crop activities are distinguished by season, variety, planting method, and irrigation technique. An important aspect of the profitability estimates for the rice crops is the implied incentives for shifting from local to modern varieties, which remain the main source of growth in rice production. As discussed in earlier chapters, the important likely shifts are from local transplant aman to HYV aman, and from local broadcast aman and aus to HYV boro.[91] The economic profitability of such a shift (in terms of the resulting gain in net economic returns per hectare) decreases with the economic price used for the valuation of rice output. The gains from the shift are quite large in the import and nontraded situations, as also in terms of private returns at the existing level of domestic rice price. These results can also be taken to imply that the irrigation investments that induce the shift to HYVs are economically profitable. However, if a move is made to the export parity price, the economic gains from the adoption of the HYVs are greatly reduced (and are almost eliminated in the case of irrigated HYV aman). It may also be noted that the economic profitability of

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[89] This reflects the actual trading status of chemical fertilizers in Bangladesh.

[90] The "standard" estimate of irrigation cost per hectare is used for HYV boro; the estimates for other crops are obtained by applying the proportionate variations in financial costs of irrigation among crops as estimated from the survey.

[91] In addition, there may be a shift from the local variety to HYV within both aus and boro seasons, although further scope for this in the boro season may be limited.

Table 5.1--Private and economic profitability of rice crops (farm level), 1990/91

Rice Crop[a]	Irrigation Technique[b]	Net Private Returns	Net Economic Returns: Export Parity	Non-Traded	Import Parity
			(Tk/hectare)		
Boro					
HYV	Modern	8,335	5,442	11,132	16,485
Local T	All	4,643	3,763	6,554	9,170
Aman					
HYV	Modern	5,805	3,626	8,563	13,202
HYV	Rainfed	10,238	8,071	13,106	17,699
HYV	All	9,550	7,429	12,262	16,804
Pajam	All	6,401	4,924	8,997	12,824
Local T	Rainfed	3,786	3,019	5,856	8,515
Local B	Rainfed	2,772	2,274	4,470	6,525
Aus					
HYV	Rainfed	7,048	5,430	9,395	13,119
HYV	Modern	5,908	3,574	8,382	12,899
HYV	All	6,418	4,738	8,833	12,681
Local B	Rainfed/traditional	-165	-306	-1,605	3,383

Notes: Profitability is estimated as net of all costs except land rent and is therefore a measure of return to land (and management). The estimates are based on "normalized" domestic and world prices of rice for 1990/91 as discussed in the text.

[a] HYV = high-yielding variety; T = transplant; Pajam = a locally improved variety; B = broadcast.

[b] Modern irrigation includes mechanized irrigation by pumps and tubewells. The category "All" includes different irrigation techniques and represents the entire sample of the respective crop in the farm survey underlying this study.

production of local aus for export is negative, indicating that in the event the land could better be left fallow or shifted to nonagricultural use (if a shift to more remunerative crops is not possible).

Among the HYV rice crops, HYV boro has the highest yield, but the rainfed HYV aman is the most profitable, evidently because there are no irrigation costs. However, the expansion of HYV aman in future may increasingly depend on provision of supplementary irrigation during the wet season. There is scope for economizing on the cost of such supplementary irrigation by utilizing the same installed irrigation facilities as are available for winter irrigation. This scope for economy is not, however, reflected in the present estimate of profitability for irrigated HYV aman since the irrigation costs for this crop are found to be rather high (see Mahmud 1993b).

There is evidently a wide range of variations between the estimates of economic profitability of rice production for export and import substitution. In the nontraded situation lying in between, the comparative advantage of rice in relation to other crops would largely depend on the evolving trends in the supply-demand balance and price determination in the domestic rice market. Moving to a rice-export regime would imply a very substantial decline in the profitability of agricultural production (and in the returns from irrigation investments) as a whole,

Table 5.2--Private and economic profitability of nonrice crops (farm level), 1990/91

Crop	Irrigation Technique	Price Parity Basis	Net Economic Returns[a]	Net Private Returns
			(Tk/hectare)	
Wheat	Modern	Import	747 (446)	184
	Nonirrigated	Import	2,701 (2,445)	2,046
	All	Import	1,757 (1,469)	1,149
Jute (white)	Rainfed	Export	5,809 (1,918)	-1,437
Jute (Tossa)	All	Export	10,822 (5,693)	2,115
Cotton	Rainfed	Import	16,625 (13,135)	10,130
Tobacco	Modern	Export	90,383	10,896
(Heat-cured)	All	Export	83,537	11,276
Sugarcane (for gur-making)	Modern	Import (Sugar)	3,106 (8,812)	44,534
	Nonirrigated	Import (Sugar)	-839 (3,525)	28,973
Oilseeds				
Mustard	Traditional/ nonirrigated	Import (Oilseed)	-726	2,730
	Traditional/ nonirrigated	Import (Oil)	-2,907	2,730
Sesame	Traditional/ nonirrigated	Import (Oil)	-6,692	-2,197
Linseed	Traditional/ nonirrigated	Import (Oil)	-719	2,256
Pulses				
Masur (lentil)	Traditional/nonirrigated	Import	10,131 (6,971)	5,816
	Traditional/nonirrigated	Export	6,320	
Gram	Traditional/nonirrigated	Import	7,698 (5,263)	4,376
Khesari	Traditional/nonirrigated	Import	7,979 (5,807)	5,286
Spices				
Chilli (dry)	Modern	Import	8,522	19,694
	Traditional/nonirrigated	Import	868	7,398
Onion	All	Import	36,697	41,538
Potato				
MV Potato[b]	Modern	Nontraded	29,247	16,043
(Fresh)	Traditional	Nontraded	32,342	19,289
	Traditional	Export	9,206	19,289
	All	Nontraded	26,402	16,698
MV Potato[b]	All	Import	45,947	16,698
(Chilled)	All	Nontraded	34,960	16,698
Local potato	All	Import	18,699	-2,412
(Fresh)		Nontraded	3,229	-2,412
Vegetables				
Brinjal	Traditional	Export	274,623	23,721
	Traditional	Nontraded	39,417	23,721
	Modern	Nontraded	48,246	47,398
Radish	Modern/traditional	Export	241,102	11,620
	Modern/traditional	Nontraded	21,608	11,620
Cucumber	Modern/traditional	Export	191,219	25,946
		Nontraded	37,858	25,946
Barbati (long-yard bean)	Traditional/nonirrigated	Export	167,244	29,731
		Nontraded	46,245	29,731
Arum	Traditional/nonirrigated	Nontraded	51,305	33,139
Tomato	Modern/traditional	Nontraded	88,775	63,462
Cabbage	Modern/traditional	Nontraded	50,657	33,770

(continued)

Table 5.2--Continued

Note: Private and economic profitability estimates are based on "normalized" domestic and world prices for 1990/91 as discussed in the text.

[a] Figures in parentheses correspond to the projected world price for 1995 deflated to the 1990/91 base. For pulses, however, this figure corresponds to the alternative lower world price of lentils.

[b] MV = modern variety.

given the dominance of rice in crop agriculture. Judging from the profitability estimates of many nonrice crops, it would appear that the country has more profitable options, compared with rice export. This in turn raises the question of sustaining the profitability of nonrice crops as well, in the face of market demand constraints. Another important consideration here is the likely effect on producer incentives in the event of moving to a rice-export regime. It remains doubtful whether the implied decline in private profitability would allow rice production to grow rapidly enough to actually generate an exportable surplus.[92]

The above observations, however, do not rule out the possibility that the export of certain special varieties of rice (such as high-quality aromatic rice) can be highly profitable in terms of both private and economic returns. While such a prospect does seem to exist, the quantities of such exports are unlikely to be large enough to significantly influence the domestic markets for the general rice varieties considered in this exercise. Rice export and import are also sometimes proposed as a short-run price stabilization measure in the face of fluctuations in domestic production. The question of comparative advantage in rice export, however, is related to longer-term supply-demand strategy and should be distinguished from short-run considerations for stabilization.[93]

At the projected lower price of rice in 1995, the farm-level import parity price is very close to the economic price in the present nontraded situation, so the corresponding profitability estimates are almost similar and are not reported separately. If so, the profitability estimates for rice in the nontraded situation presented in Table 5.1 can also be taken as the upper bound of economic profitability in the light of the projected world price of rice. At that level of world price,

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[92] To allow rice exports to take place, the actual farmgate price of rice would have to decline by about 29 to 25 percent compared with the price used here in the present estimates of private profitability. At this lower price, the net private returns from, say, HYV boro would be less than Tk 3,000 per hectare, compared with more than Tk 8,000 in the present estimates.

[93] Nevertheless, the results presented here suggest that a swing between export and import may result in an unacceptable degree of price variations in the domestic rice market, so that a more active policy in terms of food stock management may be called for.

however, rice export would not make sense, since the economic returns from most rice crops, including the HYVs, would become negative.[94]

Profitability of Nonrice Crops

Wheat. Wheat shows very weak profitability, both private and economic. Although the wheat grown in the country is now almost entirely of the modern variety, the yields are low even under irrigated conditions (Appendix 2, Table A2.15). As a result, the profitability of wheat seems to be in fact lower under modern irrigation than when grown as a nonirrigated crop. There is evidence from official crop statistics and other farm survey data regarding a decline in wheat yields in recent years (see Figure 2.2A and Islam 1991). Although the reasons for this are not clear, there is a general agreement among agricultural scientists that there may not be much further scope for profitable expansion of wheat production because of agroclimatic constraints (barring unanticipated breakthroughs in the development of heat-resistant and better-adapted wheat varieties). With world prices expected to decline in coming years, there does not seem to be any comparative advantage for Bangladesh to expand the area under wheat (see World Bank 1991, vol. 1, 24).

Jute. Jute, which is the main cash crop, appears to have higher economic profitability compared with local rice, which is its competing crop. But at the lower projected price, only the superior Tossa variety can clearly maintain this competitive edge. Because of the relatively low farmgate prices, the private profitability of jute is much lower and can even be negative. It must, however, be remembered that Bangladesh, being the world's largest exporter of jute, faces a downward-sloping foreign demand curve for its export of jute and jute products, especially raw jute. Thus, the marginal revenue earned from the export of raw jute would fall short of the f.o.b. export price, which is used here as the basis for the estimation of economic profitability. The profitability estimates for jute presented here can therefore be taken to indicate only the *average* profitability at the present level of raw jute export (or at a different level of export resulting from an autonomous shift in demand in the world jute market).[95]

[94] In interpreting these results, it must be however realized that in the event of a decline in the economic value of rice, the opportunity costs of labor and other agricultural factors of production are also likely to decline. As such, the economic profitability estimates based on the prevailing factor costs would not exactly remain valid. This would be true in the case of private costs and returns as well.

[95] While the world demand for jute export from Bangladesh is quite inelastic in the short run, the long-run elasticity is likely to be high because of the competition between jute products and its synthetic substitutes and also because of higher longer-run supply elasticities of other jute exporting countries.

<u>Sugarcane</u>. About 25-30 percent of the sugarcane produced is processed into white sugar by the state-owned refineries, and the rest is mostly used for making gur (raw sugar) by traditional methods. About half of the country's need for white sugar is currently met from imports, while there is no foreign trade in either gur or sugarcane. Because of the excessive milling costs incurred by the highly inefficient refineries, the economic (import parity) price of sugarcane at the farmgate level is likely to be very low or even negative.[96] There is evidently no comparative advantage in producing sugarcane for sugar-milling, given the existing level of milling efficiency and the current world price of sugar. Instead, the economic profitability estimates presented here correspond to the use of sugarcane for producing gur as a substitute for imported sugar. But even for gur-making, sugarcane production appears to generate negative economic returns under the predominant nonirrigated mode of cultivation, and the returns are very low even with higher yields obtained under modern irrigation. Although the world price of sugar is expected to increase, the economic returns would still appear to be low for a year-round crop like sugarcane. On the other hand, sugarcane shows very strong private profitability, made possible by the very high protection provided to the domestic sugar industry.

<u>Oilseeds</u>. Mustard seed, which makes up the largest share of oilseed production in Bangladesh, shows negative economic returns, but private profitability is positive (although modest) because of heavy protection provided to both oilseeds and edible oils. Bangladesh imports both rapeseed and rapeseed oil (which are very close substitutes for mustard seed and oil), so the local oil mills can use either imported or domestically produced oilseeds. The economic returns are lower (that is, the economic loss is larger) when import-substitution of edible oil is considered rather than that of oilseeds, which is presumably because of the inefficiency of the local oil-milling industry.[97] The economic returns from the production of other oilseeds are also found negative.

<u>Pulses</u>. Unlike oilseeds, pulses appear to be strongly competitive as a nonirrigated rabi crop in terms of both private and economic profitability. Although domestic prices are still generally lower than the import parity price, the country is on the verge of switching from self-sufficiency to an import regime, with substantial imports taking place in deficit years and lean seasons. The economic profitability of pulses

[96] This will be apparent from the large processing margins for sugar, although no attempt has been made here to convert these into economic costs (see Appendix 2, Table A2.14). Even these large margins, obtained indirectly by price comparisons, underestimate the actual financial costs of processing, since these do not reflect the large financial losses incurred by the state-owned sugar mills.

[97] An implication of this is that the country would be better off by directly importing edible oil rather than processing the imported oilseeds. The costs of oil processing by large-scale rotary mills rather than by traditional methods have been considered here. The former is the dominant method used for supplying edible oil to the urban centers.

is also estimated corresponding to a lower border price for lentils, which may be more relevant with fewer trade restrictions (such as regarding the source of supply). These lower profitability estimates, shown within parentheses in Table 5.2, are also reasonably high for a nonirrigated crop.

Spices. Among spices, chilli has very low economic profitability except when grown under modern irrigation, which is not commonly found. But because of high domestic prices, it remains strongly competitive with other rabi crops. On the other hand, onions not only show very high private returns but also a strong comparative advantage for import substitution. It may be noted that the border prices used here for chilli and onions refer to imports from India through land routes. Since India is one of the leading exporters of dried onions among developing countries, it may be worth exploring whether such prospects exist for Bangladesh as well (Islam 1990, table 46).

Potatoes. Potatoes are appropriately treated as a nontraded product for economic valuation, although estimated potential profitability has also been estimated here under alternative import and export regimes. Of the total area under potatoes, about two-thirds is now under the modern varieties, with yields that can be twice as much as those of the local varieties. The production of modern-variety potatoes for domestic consumption appears to be highly profitable, in terms of both private and economic returns, and there seems to be some export potential as well. The high profitability of chilled potatoes at the import parity price indicates that import is not desirable even during lean seasons, taking into account the economic costs of storage and chilling. In the nontraded situation, on the other hand, the economic profitability of chilled potatoes is even higher than that of fresh potatoes. It reflects the fact that consumers' preference for lean-season potatoes, as depicted by the seasonal price spread, outweighs the economic costs of storage and chilling.[98] In other words, it would be desirable to encourage the storage and chilling of potatoes, which would also have the effect of expanding the size of the domestic market. Local potatoes, in contrast, have a very poor standing, except in the unlikely situation of competing with imports--that too in the postharvest season (that is, in the fresh form).

Vegetables. Vegetables perhaps show the most promising profitability estimates. At the current level of domestic prices considered, vegetables appear to be highly competitive in terms of both private and economic returns. The economic profitability of vegetable production for export would in fact seem to be fabulously high by the standard of most other crops. However, these exports currently account for less than 1 percent of domestic production of vegetables (see Table 3.9) and mainly

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[98] The high seasonal price spread for potatoes was discussed in Chapter 2.

cater to the demands of Bangladeshi communities living in the United Kingdom and the Arab Middle East. The marketing spreads between farmgate and f.o.b. prices are excessively large, partly due to inefficiencies in export marketing, but mainly reflecting the extra profits earned by exporters in a segmented export market.

Cotton. The profitability estimate for cotton, which is grown in the aman season, suggests that it has a comparative advantage for import substitution. Even with a projected decline in the world price, its economic profitability would remain as high as that of rainfed HYV aman. The low domestic procurement price offered by the government-owned spinning mills in a monopsonistic market has a depressing effect on the profitability of cotton production, which is still higher compared with any aman rice crop. However, cotton is a very minor crop, meeting only about 10 percent of the country's total demand for cotton.

Tobacco. Tobacco is only modestly profitable as a dry-season irrigated crop in terms of private returns, but shows very high profitability when exported. The discrepancy between private and economic returns is due to very high profits earned by exporters having limited access to foreign markets.[99] Most of the tobacco produced goes to the domestic market, but since tobacco consumption is socially discouraged, it raises a problem of economic valuation of such consumption. The government policy, presently pursued, is to provide no support to tobacco production at the grower's level as well as to discourage the consumption of tobacco products through high taxes.

Expected Profitability with Technological Innovations

The profitability estimates discussed above are intended to reflect actual rather than potential farm practice. The relative profitability of crops can, however, change with technological improvements. As discussed in Chapter 3, research and extension activities in the past were mainly concentrated on HYV rice to the neglect of most other crops. Nevertheless, new technologies of some noncereal crops have already been developed and recommended for commercial cultivation (Ministry of Agriculture 1989b). In order to assess the likely impact of technological improvements on comparative advantage, profitability estimates have been derived here for a number of "synthetic" crop activities incorporating the improved production techniques.

The synthetic crop activities are constructed on the basis of the data on fertilizer recommendations and expected yields for particular improved crop varieties, as reported in the publications of the Bangladesh Agricultural Research Council (BARC 1989). These data on fertilizer input and yield rates are combined with other production

[99] Tobacco leaf is exported mainly to the United States, United Kingdom, Holland, and Sri Lanka, and exports account for less than 10 percent of domestic production.

input data of a corresponding crop activity used in the earlier profitability exercise.[100] The labor input requirements are, however, estimated by applying an elasticity of 0.3 with respect to the envisaged increase in yield rates. Also, since irrigation in varying intensities is recommended for all of the crop varieties (except rainfed jute), the irrigation costs have been estimated as appropriate proportions of those for HYV boro rice. The salient features of the crop activities, so constructed, can be seen in Appendix 2, Table A2.16.

An important aspect of the construction of these synthetic crop activities should be mentioned here. The BARC fertilizer recommendations for each crop are based on three alternative scenarios of low, medium, and high input-base, and each scenario has a range of fertilizer dose and the associated yield estimates (reflecting varying agronomic conditions). The estimates used here relate to the medium input-base scenario for all crops, taking the midpoints of the range of both yield and fertilizer dose. This has been done in order to make a realistic assessment of profitability of the crop varieties (and their competitiveness with HYV boro) in the event of their widespread adoption by farmers. It is worth noting that for HYV boro, the estimates of yield and fertilizer use in the present synthetic crop model are only slightly higher (by 8 percent and 4 percent, respectively) than those used in the earlier profitability estimates that are meant to reflect existing farm practices. Since HYV boro represents the most well-established modern seed-fertilizer technology in Bangladesh, it would be unduly optimistic to assume that the HYVs of other crops would generally achieve yields any higher than those envisaged in the medium input-base scenario.

The estimates of expected private and economic profitability of crops under technological innovations are presented in Table 5.3. As in the earlier table, the economic profitability estimates for some crops at the projected 1995 world prices are shown within parentheses. As expected, there is only a small increase in the profitability of HYV boro compared with the earlier estimates. But for most other crops, there are very substantial improvements in both economic and private profitability, reflecting the higher productivity of the crop varieties as well as the effect of better farm practice (as implicit in the BARC recommendations).

Wheat and sugarcane do not, however, appear promising in spite of the improved profitability. Under certain cropping patterns, wheat may still barely compete with HYV boro if the higher irrigation coverage made possible by growing wheat instead of rice is taken into account. But it is the case of mustard seed that is the most remarkable, in that the economic profitability remains negative, even though a substantial increase in yield (by about 40 percent) is envisaged (see Appendix 2, Tables A2.15 and A2.16). This has something to do with the low world

[100] The corresponding crop activities are so chosen as to best represent an improved-technology scenario, for example, modern-variety potatoes under modern irrigation.

Table 5.3--Expected private and economic profitability of crops with technological innovations, 1990/91

Crop	Price Parity Basis	Net Economic Returns[a]		Net Private Returns
		(Tk/hectare)		
Boro HYV[b]	Export	6,094		9,176
	Import	18,068	(12,609)	9,176
	Nontraded	12,263		9,176
Wheat	Import	6,930	(6,470)	6,227
Jute (white)	Export	12,186	(7,459)	1,621
Cotton	Import	24,247	(19,538)	15,741
Sugarcane (for gur-making)	Import	8,925	(15,796)	59,240
Mustard	Import (oil)	-3,473		4,823
	Import (oilseed)	-401		4,823
Masur (lentil)	Import (high price)	16,418		10,205
	Import (low price)	11,589		10,205
Potato (fresh)	Export	19,541		33,728
	Nontraded	52,135		33,728
Brinjal	Nontraded	120,393		88,759
Radish	Nontraded	105,060		74,013
Tomato	Nontraded	125,845		91,696

Note: Crop yield and production costs underlying the profitability estimates are based on the assumption that modern-variety seeds are used with "medium" doses of fertilizers; see Appendix 2, Table A2.16.

[a] Figures in parentheses correspond to the projected world price for 1995 deflated to the 1990/91 base.

[b] HYV = high-yielding variety.

price of oilseeds and the nature of the improved production technology that is currently available.

On the other hand, the expected private and economic returns from the improved variety of lentils are as high as those of HYV boro; this would clearly make it a preferable crop because of its much lower irrigation intensity. Both cotton and jute (even of the inferior white variety) show the potential to become even more competitive in the respective aus and aman seasons. Modern-variety potatoes, which have a competitive edge even with existing farm practice, could attain much higher profitability and a comparative advantage for export. However, the most spectacular gains in profitability would come from the adoption of certain high-yielding varieties of vegetables as featured in this exercise.

THE POLICY PERSPECTIVE

The profitability analysis gives rise to a number of conclusions, regarding incentives for crop diversification, which appear robust in spite of many conceptual and data problems underlying such an analysis. A striking feature of the profitability estimates is that a number of crops such as potatoes, vegetables, onions, and cotton show economic and private returns that are as high as or higher than those of HYV rice. While this suggests that there exists considerable potential for crop diversification, investigation is needed as to why these crops have performed so poorly, compared to HYV rice, in terms of land allocation and output growth. The answer may lie in a combination of economic and physical factors, some of which have been alluded to in earlier chapters.

There are very high price risks associated with the marketing of such crops as potatoes, vegetables, and spices (see Table 3.7). On the other hand, the existing on-farm water management systems do not allow rice and nonrice crops to be planted in the same service units. As discussed earlier, this discourages the use of modern irrigation for growing high-value, but risky, nonrice crops, since it may often require farmers to allocate all their land (or most of it) to such crops. This perhaps largely explains why land under modern irrigation is almost exclusively devoted to rice cultivation, while high-value nonrice crops are widely grown under traditional irrigation (which, being divisible, allows such crops to be grown on small parcels of land). This poses a serious problem for crop diversification, since the prospects for increasing the area under traditional irrigation is believed to be limited (Master Plan Organisation 1991). The problem needs to be solved in several ways, namely, by (1) reducing the price risks through improved marketing, (2) making the nonrice crops more profitable through technological improvements so as to compensate for high price risks, and (3) introducing water management systems that would allow rice and nonrice crops to be grown within the same service units.[101]

As discussed in Chapter 3, the prospects for agricultural growth through crop diversification depend largely on how far noncereal crops can compete with HYV boro rice under dry-season irrigated conditions. The estimates of potential profitability with technological improvements suggest that there is more unexploited technological potential for dry-season nonrice crops as compared with boro rice, even with the existing available technologies. However, the technical and socioeconomic constraints to technology adoption in the case of nonrice crops are still little understood. The cultivation of high-value crops like vegetables with improved technologies is highly resource-intensive. The improvement of marketing facilities that could reduce price risks as well as provision of credit to meet farmers' cash needs are likely to be important determining factors in the diffusion of these technologies.

The profitability estimates bring out the critical role of marketing, storage, and processing functions in determining both economic and private returns of crop production. While there is evidence of a relatively efficient rice marketing system having evolved over time, most noncereal crops have a disadvantage in this respect compared

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[101] This may require special preparation of plots, as is practiced in some Southeast Asian countries.

with rice. Marketing costs are generally high because of inadequate infrastructural facilities and because of high price risks and private traders' lack of access to institutional credit. These high costs of marketing, in turn, have a depressing effect both on the size of the market (by raising the consumer price) and on producer incentives (by lowering the farmgate price). The relatively high marketing costs in financial terms, compared with those in economic terms, can also be an important source of the divergence between private and economic profitability of crops.

It is important to examine how far the structure of incentives created by trade policies are in conformity with the country's comparative advantage. It has been already observed that, as regards rice, the trade policy has increasingly become neutral as the country approaches self-sufficiency in rice. Wheat appears to be slightly protected, although there can be little justification for such protection on the basis of comparative advantage.[102] However, the major anomaly in the incentive structure seems to be in sugarcane and oilseeds (and also chilli), which show no comparative advantage but enjoy high rates of protection. The estimates of expected profitability with technological innovations suggest that for these crops, there is even no ground for applying the "infant industry" argument, if such an argument is at all relevant for crop production. The low economic profitability of sugarcane and oilseeds as well as the prevailing high rates of protection for these crops has arisen largely from the sharp decline in the international prices of sugar and oilseeds. As discussed earlier, this decline in world prices has not been adequately reflected in the domestic price movements, particularly in the case of sugarcane, thus resulting in the present level of distortions in the incentive structure.[103]

On the other hand, the trend decline in the world price of pulses was much smaller when compared with other agricultural commodities (see Table 4.4). This, along with the fact that the country has become an importer of pulses, largely explains why this crop now appear to have a relatively high economic value. However, at the prevailing domestic prices, there is hardly any protection provided to pulses.[104] The price of potatoes has also declined relatively modestly in the world market, so that there is some potential for potato export to be economically profitable. As regards vegetables, although domestic prices are found far too low compared with export prices, this cannot be blamed on the trade policies being pursued. This is rather a reflection of limited

[102] With the grain imports being recently liberalized, there is an ongoing policy debate as to whether duty-free wheat import by private traders should be allowed.

[103] Admittedly, the world price of sugar is highly volatile, and the subsidized oilseed export by Western Europe has been a subject of intense controversy in recent debates on international trade reforms. These do not, however, seem to be sufficient grounds for revising our assessment of comparative advantage in these crops.

[104] Import of pulses mostly take place in deficit years and lean seasons.

access to the world market and a lack of infrastructural facilities for export. Nevertheless, the estimates of high economic profitability of vegetable export point to the need for government support to promote such export. There is some negative protection in the case of jute and cotton, although these crops are found economically competitive. In both the cases, the prices are kept low to the advantage of public-sector industries (although in the case of raw jute, there is also a case for export taxation because of the inelastic world demand). Onion perhaps provides the only example, among the crops under study, of a positive (and moderately high) rate of protection being associated with high economic profitability.

Another way of looking at the profitability estimates for nonrice crops is that the country does not seem to have a comparative advantage in those items that currently compete with major imports, namely, wheat, sugar, oilseeds, and edible oils.[105] On the other hand, the crops that show high economic profitability, such as potatoes and vegetables, are currently produced either entirely for the domestic market or have only limited access to the world market. While import substitution, by its very nature, does not encounter a market problem, the profitability of nontraded crops would depend on the growth of domestic demand in relation to output growth. (Another related aspect is that, while import liberalization for, say, sugar and edible oils would create pressures on the balance of payments, shifting to nontraded crops would not have a compensating favorable impact.) The domestic markets for noncereal crops, especially the high-value ones, are limited in size because of the generally low living standards in the economy. This underscores the need for exploring the possibility of export of crops for which there is a potential comparative advantage.[106] It should be noted, however, that in the past the production of vegetables, potatoes, spices, and fruits did not grow rapidly enough even to satisfy the growth in domestic demand, much less to create an exportable surplus. Efforts at export promotion therefore need to be part of an integrated strategy of technological improvements and development of marketing and processing facilities that could elicit better supply responses.

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[105] Cotton and onions seem to be exceptions, but cotton is a very minor crop and onions are not an important import item.

[106] The list of such crops may include high-quality rice and many horticultural products and spices that have not been included in the present profitability exercise.

APPENDIX 1: ALGEBRAIC FORMULATION OF EQUILIBRIUM EXCHANGE RATE

We assume that $-\eta_d$ and η_s are the price elasticities of import and export, respectively, while Q_d and Q_s represent the demand for and the supply of foreign exchange, respectively. Thus, in a free-trade situation, $\eta_s Q_s + \eta_d Q_d$ measures the reduction in excess demand for foreign exchange (that is, the current account deficit) due to a one unit increase in the exchange rate. Assume now that the tariff equivalent of protection (that is, the implicit tariff on import) is t_m and the implicit export tax is t_x. Eliminating both measures would lead to an increase, ΔQ_1, in excess demand for foreign exchange, where

$$\Delta Q_1 = \frac{t_m}{1+t_m} Q_d \eta_d - \frac{t_x}{1-t_x} Q_s \eta_s . \qquad \text{(A1.1)}$$

It can be then shown that the equilibrium exchange rate, which obtains when $t_x = t_m = 0$, would be given by

$$e^* = \left(\frac{\Delta Q_1}{\eta_s Q_s + \eta_d Q_d} + 1 \right) e^o , \qquad \text{(A1.2)}$$

where e^o is the prevailing official exchange rate. This would be so since the proportionate change in the exchange rate needed to eliminate an excess demand of ΔQ_1 due to the elimination of implicit trade taxes is given by $\Delta Q_1/(\eta_s Q_s + \eta_d Q_d)$.

The above formulation assumes that the entire existing current account deficit is sustainable in the free-trade situation. In the actual empirical computations, it is further assumed that both elasticities are unity in absolute terms ($\eta_s = \eta_d = 1$), and the estimates of ΔQ_1 and e^* are obtained accordingly. The existing values of Q_d and Q_s are estimated by the actual volume of imports and exports, respectively. Export earnings are estimated so as to include net remittances from abroad (mainly consisting of remittances from Bangladeshi migrants working abroad).

APPENDIX 2: SUPPLEMENTARY TABLES

Table A2.1--Growth of production and value added in crop agriculture: comparison with official estimates

Year	Authors' Estimate of Crop Production at 1984/85 Prices: Gross Value	Authors' Estimate of Crop Production at 1984/85 Prices: Annual Growth	Official Estimate of Crop Sector Value Added at 1984/85 Prices: Value Added	Official Estimate of Crop Sector Value Added at 1984/85 Prices: Annual Growth
	(Tk million)	(percent)	(Tk million)	(percent)
1972/73	101,702	...	87,093	...
1973/74	112,920	11.03	96,169	10.42
1974/75	107,754	-4.58	90,353	-6.05
1975/76	117,857	9.38	102,071	12.97
1976/77	112,595	-4.46	95,778	-6.17
1977/78	122,774	9.04	104,167	8.76
1978/79	123,095	0.26	105,079	0.88
1979/80	122,338	-0.61	105,193	0.11
1980/81	129,883	6.17	114,321	8.68
1981/82	128,081	-1.39	122,674	7.31
1982/83	133,404	4.16	127,784	4.17
1983/84	135,307	1.43	133,921	4.80
1984/85	136,925	1.20	135,031	0.83
1985/86	140,616	2.70	139,599	3.38
1986/87	140,564	-0.04	139,596	0.00
1987/88	139,189	-0.98	137,119	-1.77
1988/89	137,766	-1.02	134,509	-1.90
1989/90	154,150	11.89	150,828	12.13

Sources: Gross value of crop production is the authors' estimate based on official data with certain adjustments as described in the text; see also Table 2.1 in the text and Table A2.2 in this appendix. Crop sector value added is the official estimate from the national income series of the Bangladesh Bureau of Statistics as reported in World Bank, Bangladesh: Selected Issues in External Competitiveness and Economic Efficiency, Report No. 10265-BD (Washington, D.C.: World Bank, 1992).

Table A2.2--Index of production in crop agriculture (1984/85 = 100)

Crop	FY 73	FY 74	FY 75	FY 76	FY 77	FY 78	FY 79	FY 80	FY 81	FY 82	FY 83	FY 84	FY 85	FY 86	FY 87	FY 88	FY 89	FY 90
Foodgrains	65	77	73	83	77	85	85	85	94	91	96	98	100	101	103	103	103	118
Paddy	69	81	77	87	81	89	88	87	95	93	97	99	100	103	105	105	105	122
Wheat	6	8	8	15	18	24	34	56	75	66	75	83	100	71	75	72	70	61
Nonfoodgrains	99	97	95	95	97	103	104	100	98	100	102	101	100	107	101	98	94	97
Jute	127	117	68	77	94	105	126	117	97	91	95	102	100	169	132	92	87	91
Oilseeds	88	82	92	93	90	103	103	92	91	93	93	96	100	96	88	90	86	88
Pulses	110	102	112	110	116	120	114	109	106	103	104	96	100	94	92	96	90	92
Spices	109	100	105	105	97	102	103	102	86	98	99	99	100	99	100	103	105	113
Fruits	103	105	98	99	100	98	94	96	99	100	104	98	100	99	104	100	94	99
Vegetables	81	81	85	87	82	87	89	89	92	96	100	102	100	101	102	106	108	114
Tubers	74	71	83	87	75	88	88	88	90	96	100	102	100	94	89	103	90	88
Sugarcane	79	94	98	87	95	99	101	94	96	104	107	104	100	97	100	105	98	108
Tea	64	72	85	78	89	98	101	97	105	102	108	111	100	114	99	107	115	103
Minor cereals	227	227	220	208	190	203	177	169	165	163	138	117	100	92	75	69	66	64
All crops	74	82	79	86	82	90	90	89	95	94	97	99	100	103	103	102	101	113

Notes: FY = Fiscal year. The production indices are based on time series of gross value of production at 1984/85 farmgate prices. See Table 2.1 and discussion in the text.

Table A2.3--Area and production of main nonrice crops (five-year averages)

Crop	Area 1973/74-1977/78	Area 1979/80-1983/84	Area 1985/86-1989/90	Production 1973/74-1977/78	Production 1979/80-1983/84	Production 1985/86-1989/90
	(1,000 hectares)			(1,000 metric tons)		
Wheat	150	521	575	211	1,038	1,019
Jute	672	647	686	855	930	1,059
Sugarcane	147	157	171	6,489	6941	6,975
Potato	87	105	113	833	1,065	1,121
Sweet potato	68	68	53	737	723	555
Tea	43	44	46	32	40	41
Tobacco	53	51	48	48	47	41
Oilseeds						
Rape and mustard	375	374	341	223	239	227
Sesame	132	107	85	73	59	49
Linseed	74	79	74	38	40	44
Groundnut	34	35	35	44	37	40
Pulses						
Gram	122	120	103	89	85	74
Mung	55	61	59	34	33	32
Masur	231	257	215	155	159	156
Mashkalai	115	96	69	88	68	48
Khesari	275	283	232	207	195	168
Fruits						
Banana	37	41	40	584	665	676
Mango	42	45	48	276	190	162
Watermelon	7	9	10	104	111	118
Pineapple	14	14	13	149	149	140
Vegetables						
Tomato	8	9	11	57	68	80
Radish	11	14	18	87	111	150
Brinjal	26	28	27	182	182	167
Spices						
Chilli	77	76	68	48	45	46
Onion	32	33	34	146	129	139

Note: For pulses, oilseeds, and minor cereals, consistent time series of area and production are derived by adjusting the official data as described in the text.

Table A2.4--Area under crops (five-year averages)

Crop	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90
			(1,000 hectares)		
Foodgrains	10,132	10,424	10,933	11,042	10,981
Rice	9,982	10,096	10,412	10,473	10,406
Wheat	150	328	521	569	575
Nonfoodgrains	3,473	3,580	3,365	3,263	3,091
Jute	672	722	647	754	686
Oilseeds	644	661	626	594	568
Pulses	871	941	874	774	171
Spices	151	152	150	146	143
Fruits	138	143	151	157	163
Vegetables	115	121	132	142	154
(winter)	72	77	83	88	95
(summer)	43	44	49	53	60
Potato	87	93	105	109	113
Sweet potato	68	71	68	60	53
Sugarcane	147	149	157	164	727
Tea	43	43	44	45	46
Minor cereals	390	340	266	173	126
Others	147	144	145	145	141
Gross cropped area	13,605	14,004	14,298	14,305	14,072
Net cropped area	9,124	9,128	9,132	9,162	9,204

Notes: Consistent time series of area under pulses, oilseeds, and minor cereals have been derived by adjusting the official data as discussed in the text. Major revisions have been made in the official estimates of net cropped area and fallow land since 1987/88. For consistency with earlier periods, the estimate of net cropped area for the last five-year period shown in this table and used elsewhere in this study is the average of 1985/86 and 1986/87.

Table A2.5--Area under rice crops (five-year averages)

Crop	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90
			(1,000 hectares)		
Aus	3,218	3,153	3,118	2,997	2,697
Local	2,912	2,738	2,651	2,504	2,237
Modern-variety	306	415	467	493	460
Aman	5,702	5,888	6,013	5,957	5,694
Broadcast	1,746	1,655	1,558	1,395	1,161
Local transplant	3,395	3,536	3,466	3,439	3,184
Modern-variety	561	688	985	1,128	1,348
Boro	1,062	1,064	1,289	1,519	2,016
Local	447	402	386	333	309
Modern-variety	615	664	903	1,186	1,707
All rice	9,982	10,104	10,420	10,473	10,406

Source: Based on official data as reported in various publications of the Bangladesh Bureau of Statistics.

Table A2.6--Irrigated area under different crops (five-year averages)

Crop	1973/74-1977/78	1976/77-1980/81	1979/80-1983/84	1982/83-1986/87	1985/86-1989/90
			(1,000 hectares)		
Aus	75.5	93.2	119.0	147.9	146.7
Aman	96.6	107.1	161.3	177.9	193.3
Boro	993.7	970.8	1,077.3	1,249.0	1,642.7
Wheat	49.8	135.2	193.0	244.4	253.0
Pulses	1.5	1.8	2.4	2.8	2.9
Oilseeds	2.4	3.8	4.8	9.2	12.9
Potato	52.9	64.3	71.9	70.6	69.6
Vegetables	37.2	42.5	45.0	50.9	55.5
Sugarcane	8.2	9.5	8.7	8.7	10.8
Other crops	46.6	47.5	57.1	66.2	75.8
Total	1,364.4	1,475.5	1,740.3	2,027.4	2,463.1
Irrigation of which: Modern irrigation[a]	646.8	741.0	1,031.3	1,452.8	1,941.9

Source: Based on official data as reported in various publications of the Bangladesh Bureau of Statistics.

[a] Includes irrigation by deep and shallow tubewells and power pumps.

Table A2.7--Harvest price indices and the general wholesale price index (base: 1985/86)

Year	Paddy[a]	Pulses	Oilseeds	Spices	Vegetables	All Crops	General Wholesale
1972/73	24.2	12.6	20.7	14.8	10.4	22.1	19.6
1973/74	36.4	27.5	40.1	27.5	24.7	34.2	27.4
1974/75	76.2	35.2	72.9	65.3	32.0	66.2	43.7
1975/76	44.1	28.1	43.9	34.7	27.2	41.9	39.3
1976/77	44.3	25.1	48.4	35.8	27.5	42.7	39.6
1977/78	49.5	33.2	54.0	46.5	34.0	49.6	44.6
1978/79	59.0	35.9	48.1	42.4	48.9	56.5	48.8
1979/80	64.1	43.0	57.3	44.4	63.7	60.8	54.9
1980/81	64.7	62.4	70.4	78.7	52.6	64.4	59.1
1981/82	73.7	62.1	60.9	56.8	49.4	70.4	66.6
1982/83	80.7	59.8	63.6	55.2	47.3	75.1	70.4
1983/84	94.5	73.6	100.1	104.5	85.1	91.2	81.7
1984/85	109.1	66.3	90.3	110.1	82.1	110.5	95.7
1985/86	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1986/87	126.0	112.6	104.6	124.8	117.0	114.7	108.1
1987/88	130.0	103.7	102.3	146.8	87.3	123.4	114.7
1988/89	132.0	154.4	121.4	119.4	165.5	137.9	123.5
1989/90	123.7	145.9	118.3	135.3	122.5	129.6	134.0

Sources: Authors' estimates based on the official data on harvest prices of crops as reported by the Bangladesh Bureau of Statistics (BBS). The general wholesale price index is that of BBS converted to the 1985/86 base.

Notes: Harvest price indices are constructed by using Laspeyres' formula with 1985/86 as the base year. All important crops are included in the construction of the price indices for the respective crop groups and for all crops.

[a] Estimated from price indices of boro, aus, and aman paddy.

Table A2.8--Estimated population, per capita gross domestic product, and per capita availability of selected items

Year	Population	Annual Per Capita GDP[a]	Rice	Wheat	Pulses	Edible Oil	Potato[b]	Sugar	Gur[c]	Vegetables
	(millions)	(taka)	(grams/day/capita)							
1972/73	74.3	3,041	349.59	94.47	22.27	4.47	49.21	3.54	14.94	24.85
1973/74	76.1	3,385	389.23	61.77	20.13	3.90	45.30	4.65	14.29	23.93
1974/75	77.9	3,282	366.87	76.32	21.36	5.15	51.75	3.52	13.97	25.13
1975/76	79.7	3,344	408.50	44.03	20.55	6.13	53.53	5.50	12.66	24.89
1976/77	81.6	3,315	361.64	28.12	21.27	4.49	46.03	4.93	11.73	22.86
1977/78	83.6	3,467	392.81	56.28	21.43	6.33	51.18	4.92	10.20	23.75
1978/79	85.5	3,604	371.96	50.89	20.01	5.69	50.23	4.23	12.29	23.87
1979/80	87.5	3,575	381.56	88.76	18.60	5.93	49.21	2.94	12.15	23.38
1980/81	89.5	3,851	384.95	62.13	17.76	7.54	47.96	5.20	10.57	23.42
1981/82	91.3	3,907	372.41	60.93	16.92	6.28	49.32	6.06	9.71	23.96
1982/83	93.1	4,010	389.34	87.12	16.98	6.67	50.42	5.24	10.79	24.56
1983/84	95.0	4,122	381.83	88.20	14.48	5.80	49.86	4.59	11.06	24.69
1984/85	96.9	4,200	391.94	93.87	15.24	7.07	47.92	2.60	12.23	23.92
1985/86	98.8	4,296	376.32	60.22	13.98	10.40	43.73	6.04	11.91	23.56
1986/87	100.8	4,388	384.05	69.81	13.49	11.34	40.44	8.13	8.78	23.29
1987/88	102.8	4,426	387.78	89.93	15.15	14.12	44.94	7.99	9.50	23.97
1988/89	104.9	4,449	367.03	80.49	13.52	13.52	39.24	6.97	10.54	23.96
1989/90	107.0	4,651	419.37	53.76	15.86	13.82	37.18	8.60	9.32	24.73

[a] Based on the new national income series of BBS at 1984/85 prices.

[b] Includes potato and sweet potato.

[c] Raw sugar made by traditional methods.

Table A2.9--Harvest price indices of selected agricultural commodities (1985/86 = 100)

Year	Wheat	Masur	Mustard	Onion	Chilli	Sugarcane	Jute	Potato
1972/73	18.9	11.6	21.0	8.1	11.9	16.3	26.7	24.2
1973/74	45.7	25.0	39.8	32.1	55.3	24.4	24.7	51.3
1974/75	83.6	30.5	75.5	34.5	190.9	48.7	41.6	62.1
1975/76	34.0	26.8	46.1	36.1	54.4	42.6	40.0	54.0
1976/77	47.2	27.8	49.6	21.5	82.2	42.9	53.7	36.6
1977/78	48.3	32.5	54.9	32.0	108.4	45.3	74.6	46.3
1978/79	48.7	38.1	46.8	34.6	61.7	51.4	62.9	60.0
1979/80	61.1	42.7	54.3	49.5	69.1	57.1	47.5	50.8
1980/81	65.9	63.0	68.6	81.3	161.5	62.4	57.9	56.3
1981/82	80.0	66.3	59.2	67.9	79.0	67.8	63.0	45.0
1982/83	88.3	61.3	58.7	57.5	83.4	67.8	91.6	40.4
1983/84	86.0	65.4	93.3	48.8	234.8	69.4	96.4	92.6
1984/85	91.4	60.2	84.2	87.4	205.5	79.6	205.8	78.5
1985/86	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1986/87	116.5	121.9	106.8	95.2	185.6	104.0	54.5	128.7
1987/88	114.3	106.5	97.7	151.5	193.1	104.0	140.5	77.6
1988/89	125.4	140.5	115.8	144.2	159.1	118.4	110.1	189.6
1989/90	135.7	139.2	110.7	103.1	256.1	164.6	138.6	126.2

Sources: Estimated from harvest prices reported in the various issues of Yearbook of Agricultural Statistics of Bangladesh and Statistical Yearbook of Bangladesh; the prices for 1989/90 are from unpublished data of the Bangladesh Bureau ofStatistics.

Note: Harvest prices are those prevailing in the primary markets during the harvesting seasons of respective crops.

Table A2.10--Estimated border prices of selected commodities and world inflation index

Year	Rice	Wheat	Lentil	Potato	Rapeseed	Sugar	Jute	World Inflation Index (1985=100)[b]
	Commodity[a]							
	(US$/metric ton)							
1973/74	482	211	...	134	408	700	276	59.3
1974/75	319	188	...	138	322	488	397	65.9
1975/76	240	139	...	96	261	276	280	66.8
1976/77	268	135	469	107	327	201	304	73.4
1977/78	361	153	377	106	312	194	372	84.5
1978/79	325	190	581	100	331	240	431	95.7
1979/80	421	209	678	152	345	678	342	104.9
1980/81	465	231	758	210	341	426	293	105.3
1981/82	291	207	566	158	325	230	281	103.7
1982/83	276	188	357	158	351	216	275	101.4
1983/84	265	183	437	155	353	145	366	99.2
1984/85	230	168	657	116	309	120	729	100.0
1985/86	206	145	508	141	268	163	358	117.9
1986/87	230	139	508	122	191	173	281	129.5
1987/88	309	172	402	159	259	251	358	138.9
1988/89	317	202	554	182	252	313	370	137.9
1989/90	288	169	659	168	229	309	392	146.1
1990/91	324	155	738	166	208	224	408	153.5

[a] The prices shown for jute are f.o.b. export price; prices for all other commodities are c.&f. import price.

[b] Unit value index in U.S. dollar terms of manufactures exported from the industrially developed countries to the developing countries, as estimated by the World Bank's International Trade Division.

Table A2.11--Estimated border prices of selected commodities at official exchange rate

Year	Rice (Import Parity)	Rice (Export Parity)	Wheat (Import Parity)	Lentil (Import Parity)	Potato (Import Parity)	Potato (Export Parity)	Rapeseed (Import Parity)	Sugar (Import Parity)
	(Tk/metric ton)							
1973/74	4,185	3,107	1,612	...	1,391	74	2,864	5,911
1974/75	3,265	2,053	1,479	...	1,627	206	2,120	4,747
1975/76	4,078	2,815	2,132	...	1,880	426	3,525	4,604
1976/77	4,580	3,350	2,035	7,808	2,064	640	4,556	3,529
1977/78	5,926	4,676	2,261	6,293	2,030	595	4,169	3,376
1978/79	5,443	4,043	2,830	9,480	1,983	338	4,544	4,132
1979/80	7,084	5,212	3,143	11,238	2,877	549	4,768	11,045
1980/81	8,184	6,019	3,619	13,124	3,974	1,228	4,780	7,509
1981/82	6,535	4,158	3,990	12,258	3,814	825	5,850	5,285
1982/83	7,305	5,148	4,240	9,467	4,412	1,838	7,641	5,821
1983/84	7,437	5,053	4,383	11,973	4,617	1,794	7,755	4,399
1984/85	6,881	4,287	4,184	18,247	3,850	810	7,048	3,989
1985/86	7,216	4,226	4,178	16,553	5,180	1,670	6,908	5,877
1986/87	8,223	5,142	4,103	17,098	4,832	1,346	4,713	6,437
1987/88	10,956	7,629	5,233	14,222	6,152	2,418	7,013	9,074
1988/89	11,533	7,920	6,252	19,556	7,070	2,923	6,746	11,333
1989/90	10,943	7,074	5,290	23,590	6,847	2,420	6,206	11,546
1990/91	13,190	8,723	5,316	28,429	7,401	2,201	6,094	9,528

Sources and notes: For rapeseed and wheat, the price parity is at the farmgate level; for all other commodities, border prices are at the wholesale level. For methodology of estimation, see discussion in the text; c.&f. and f.o.b. prices are reported in Table A2.10 in this appendix.

Table A2.12--Estimated border prices of selected commodities at equilibrium exchange rate

Year	Rice (Import Parity)	Rice (Export Parity)	Wheat (Import Parity)	Lentil (Import Parity)	Potato (Import Parity)	Potato (Export Parity)	Rapeseed (Import Parity)	Sugar (Import Parity)
				(Tk/metric ton)				
1973/74	6,231	4,916	2,509	...	1,961	250	4,597	8,884
1974/75	4,569	3,163	2,248	...	2,192	450	3,437	6,742
1975/76	4,944	3,586	2,633	...	2,226	614	4,469	5,600
1976/77	5,731	4,388	2,614	9,827	2,523	912	5,961	4,392
1977/78	7,490	6,126	2,922	7,926	2,488	864	5,519	4,214
1978/79	6,290	4,804	3,327	10,994	2,244	456	5,407	4,758
1979/80	8,492	6,439	3,842	13,509	3,386	756	5,922	13,315
1980/81	9,814	7,422	4,428	15,778	4,709	1,585	5,975	9,001
1981/82	7,675	5,079	4,803	14,474	4,435	1,082	7,124	6,088
1982/83	8,570	6,250	5,098	11,103	5,133	2,289	9,248	6,808
1983/84	9,229	6,600	5,620	14,925	5,665	2,437	10,144	5,380
1984/85	8,634	5,764	5,467	23,260	4,736	1,237	9,406	4,905
1985/86	8,297	5,117	4,938	19,216	5,919	2,095	8,314	6,731
1986/87	8,985	5,804	4,565	18,785	5,238	1,584	5,347	7,012
1987/88	12,401	8,930	6,036	16,100	6,895	2,920	8,224	10,246
1988/89	12,765	9,007	7,037	21,709	7,777	3,390	7,726	12,549
1989/90	12,147	8,117	5,995	26,341	7,549	2,855	7,164	12,836
1990/91	14,505	9,860	5,944	31,418	8,075	2,579	6,988	10,436

Sources and notes: For rapeseed and wheat, the price parity is at the farmgate level; for all other commodities, border prices are at the wholesale level. For methodology of estimation, see discussion in the text; c.&f. and f.o.b. prices are reported in Table A2.10 in this appendix.

Table A2.13--Domestic prices of certain commodities used in border-to-domestic price comparisons

Year	Rice (Wholesale)[a]	Wheat (Farmgate)	Lentil (Wholesale)	Potato (Wholesale)	Rapeseed (Farmgate)	Sugar (Wholesale)
			(Tk/metric ton)			
1973/74	2,831	2,080	...	1,661	4,519	4,181
1974/75	5,779	3,805	...	2,330	8,580	5,236
1975/76	3,382	1,546	...	2,368	5,241	6,712
1976/77	3,023	2,149	4,620	1,622	5,635	6,820
1977/78	3,877	2,198	6,154	1,409	6,240	6,821
1978/79	4,216	2,216	7,317	1,930	5,320	6,448
1979/80	5,657	2,783	8,573	2,254	6,173	9,870
1980/81	4,770	3,000	10,699	2,640	7,797	17,500
1981/82	6,060	3,644	12,887	2,358	6,722	15,570
1982/83	6,700	4,019	11,038	1,822	6,669	14,040
1983/84	7,450	3,914	11,762	3,081	10,594	14,790
1984/85	8,250	4,160	11,038	2,679	9,564	15,350
1985/86	6,620	4,552	15,620	3,108	11,359	21,270
1986/87	9,160	5,218	19,050	4,900	11,938	19,240
1987/88	9,970	5,201	19,960	3,780	11,095	20,440
1988/89	9,810	5,718	21,520	5,950	13,169	23,000
1989/90	9,600	6,178	22,630	6,520	12,574	27,520
1990/91	10,650	6,162	17,897	4,668	12,057	27,110

Source: Official price data as reported in the various publications of the Bangladesh Bureau of Statistics.

[a] Coarse-quality rice.

Table A2.14--Prices and marketing (and processing) margins used for estimating private and economic profitability of crops, 1990/91

Crop/Price Parity Basis	C.&F./ F.O.B. Price	Port-to-Wholesale Costs[a]	Wholesale Price	Marketing and Processing Margin	Weight Conversion[b]	Farmgate Price
	(US$/ metric ton)	(Tk/metric ton)				(Tk/ metric ton)
Rice/Paddy (Coarse)						
Financial		1,611 (1,286)	10,930	2,190	0.675	5,900
Economic						
Import	318	1,548	12,898	1,730	0.675	7,539
Export	278	1,090	8,832	1,536	0.675	4,925
Nontraded			10,930	1,641	0.675	6,270
Wheat						
Financial		1,449	8,941	2,779	1.00	6,162
Economic: import	181	1,336	7,796	1,832	1.00	5,964
Jute (white)						
Financial		1,425	11,667	4,975	1.00	6,691
Economic: export	400	1,218	13,058	2,659	1.00	10,399
Jute (Tossa)						
Financial			13,330	5,263	1.00	8,067
Economic: Export			14,920	2,776	1.00	12,144
Cotton						
Financial		3,517	63,700	9,554	0.325	17,580
Economic: import	1,928	4,042	72,852	7,382	0.325	21,144
Sugar/sugarcane						
Financial		1,528	27,810	15,879	0.087	1,038
Economic: import (sugar)	291	1,459	11,845			
Gur/sugarcane						
Financial			17,798	7,418	0.100	1,038
Economic: import (sugar)			7,581	3,689	0.100	389
Mustard						
Financial (oil/seed)		11,501[c]	56,000	14,380	0.300	12,498
Financial (seed)		1,511	15,881	3,383	1.00	12,498
Economic						
Import (oil)	459	10,824[c]	27,206	10,233	0.300	5,097
Import (seed)	237	1,419	9,878	22,265	1.00	7,612
Sesame						
Financial (oil/seed)			48,140	14,970	0.350	11,598
Economic: import (oil)			23,387	9,242	0.350	4,944
Masur (lentil)						
Financial		2,104 (1,450)	23,290	6,000	0.857	14,825
Economic						
Import (high price)	665	2,162	25,896	3,296	0.857	19,378
Export (high price)	609	1,241	20,495	2,958	0.857	15,036
Import (low price)	532	2,103	21,090	2,995	0.857	15,515
Chilli (dry)						
Financial		2,142	50,000	5,290	1.00	44,710
Economic: import	902	2,240	34,432	4,332	1.00	30,100
Onion						
Financial		2,142	11,700	3,300	0.950	7,980
Economic: import	211	1,932	9,462	2,060	0.950	7,030

(continued)

Table A2.14--Continued

Crop/Price Parity Basis	C.&F./ F.O.B. Price	Port-to-Wholesale Costs[a]	Wholesale Price	Marketing and Processing Margin	Weight Conversion[b]	Farmgate Price
	(US$/ metric ton)	(Tk/metric ton)				(Tk/ metric ton)
Potato (fresh)						
Financial		1,466 (1,126)	4,580	1,780	1.00	2,800
Economic						
Import	177	1,350	7,668	1,178	1.00	6,490
Export	109	943	2,948	953	1.00	1,995
Nontraded			4,580	1,030	1.00	3,550
Potato (chilled)						
Financial		1,466 (1,126)	6,800	4,000	1.00	2,800
Economic						
Import	177	1,350	7,668	2,981	1.00	4,687
Nontraded			6,800	2,868	1.00	3,932
Tobacco (heat-cured)						
Financial: export				64,181	1.00	24,500
Economic: export	2,485			17,061	1.00	71,665
Brinjal						
Financial: Nontraded			6,652	2,612	1.00	4,040
Economic: Nontraded			6,652	1,554	1.00	5,098
Vegetables						
Financial: export				27,000-31,000[d]	1.00	3,000-7,000[d]
Economic: export	954			9,775	1.00	24,262

Note: For sources of data and methodology of estimation see discussion in text and W. Mahmud, Structure of Incentives and Comparative Advantage in Bangladesh Agriculture, background paper of the IFPRI-BIDS Agricultural Diversification Study (Dhaka: Bangladesh Institue of Development Studies 1993).

[a] Figures in parentheses show the financial margins between the wholesale market and the port in the case of exports.

[b] The weight conversion is due to processing; it may include in some cases the loss of weight during storage.

[c] Includes costs of processing of imported oil in crude form.

[d] Shows the range of variation among individual products.

Table A2.15--Crops yields and the use of labor and chemical fertilizer in crop production activities

Crop[a]	Irrigation Technique	Yield[b]	Labor[c]	Fertilizer[d]
		(kilograms/ hectare)	(person-days/ hectare)	(kilograms/ hectare)
Boro paddy				
HYV	Modern	4,344	198	360
Local T	All	2,189	135	69
Aman paddy				
HYV	Modern	3,588	215	276
	Rainfed	3,531	184	261
	All	3,499	189	259
Pajam	All	2,956	194	173
Local T	Rainfed	2,096	160	79
Local B	Rainfed	1,646	132	26
Aus paddy				
HYV	Rainfed	2,998	164	226
	Modern	3,627	202	262
	All	3,090	178	242
Local B	Rainfed/ traditional	1,554	161	85
Wheat	Modern	2,292	159	313
	Nonirrigated	1,959	146	193
	All	2,199	156	272
Jute (white)	Rainfed	1,530	247	111
Jute (tossa)	All	1,765	245	136
Cotton	Rainfed	1,306	211	235
Tobacco	Modern	1,577	236	347
	All	1,445	255	347
Sugarcane	Modern	71,333	318	692
	Nonirrigated	54,550	341	511
Oilseeds				
Mustard	Traditional/ nonirrigated	894	118	207
Sesame	Nonirrigated	775	196	91
Linseed	Nonirrigated	508	51	32
Pulses				
Masur (lentil)	Traditional/ nonirrigated	818	82	92
Gram	Nonirrigated	767	81	55
Khesari	Nonirrigated	1,088	73	6
Spices				
Chilli (dry)	Modern	897	264	443
	Traditional/ nonirrigated	699	407	223
Onion	All	8,078	321	192
Potato				
MV Potato	Modern	19,417	299	819
	Traditional	18,372	314	562
	All	18,502	295	695
Local Potato	All	7,961	237	327

(continued)

Table A2.15--Continued

Crop[a]	Irrigation Technique	Yield[b]	Labor[c]	Fertilizer[d]
		(kilograms/ hectare)	(person-days/ hectare)	(kilograms/ hectare)
Vegetables				
Brinjal	Traditional	12,273	391	464
	Modern	16,484	514	824
Radish	Modern/ traditional	10,722	267	433
Cucumber	Modern/ traditional	8,449	164	317
Tomato	Modern/ traditional	16,365	332	372
Cabbage	Modern/ traditional	19,909	275	502
Barbati (long-yard bean)	Traditional/ nonirrigated	7,696	352	304
Arum	Traditional/ nonirrigated	13,912	296	653

Source: The estimates are mainly based on the findings of the farm survey underlying the present study, but some reconciliation with other survey findings has been made, as discussed in the text.

Note: Figures correspond to the estimates of economic and financial profitability presented in Tables 5.1-5.3.

[a] HYV = high-yielding variety; T = transplant; Pajam = a locally improved variety; B = broadcast; MV = modern variety.

[b] Does not include by-products.

[c] Includes the use of labor in traditional irrigation and in certain postharvest operations.

[d] Chemical fertilizers other than urea, TSP, and MP are not included.

Table A2.16--Data on crop production activities used for estimating expected profitability with technological innovations

Crop Variety	Yield	Fertilizer	Labor	Cost of Irrigation
	(metric tons/ hectare)	(kilograms/ hectare)	(person-days/ hectare)	(Tk/hectare)
Boro paddy (HYV)	4.70	374	203	5,000
Wheat (Balaka/Sonalika)	3.50	335	184	1,667
Jute (white) (D-154, CVL-1, CVE-3, CC-45)	2.25	104	282	0
Cotton (all varieties)	1.8	407	235	1,000
Lentil (L-5)	1.25	166	95	1,000
Mustard (SS-75)	1.25	352	132	1,000
Potato (Cardinal)	25.00	473	324	1,667
Sugarcane (ISD-2/54, ISD-16, ISD-19)	95.00	683	335	1,000
Brinjal (Rajshahi-3)	32.50	584	664	1,000
Radish (Tasakisan I, Mino Early, Miyashigi)	35.00	595	448	1,667
Tomato (Summarizona, Ox Heart)	22.50	617	369	1,667

Note: For the methodology of estimation and sources of data, see the discussion in the text.

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