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COMPARATIVE ADVANTAGE IN BANGLADESH CROP PRODUCTION

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ABSTRACT

This study uses data from 1996/97 through 1998/99 to examine the relative efficiency of production of crops in Bangladesh and their comparative advantage in international trade as measured by net economic profitability (the profitability using economic, rather than financial costs and prices), and the domestic resource cost ratio, (the amount of value of non-tradable domestic resources used in production divided by the value of tradable products).

The economic profitability analysis demonstrates that Bangladesh has a comparative advantage in domestic production of rice for import substitution. However, at the export parity price, economic profitability of rice is generally less than economic profitability of many non-rice crops, implying that Bangladesh has more profitable options other than production for rice export.

Several non-cereal crops, including vegetables, potatoes and onions have financial and economic returns that are as high as or higher than those of High Yielding Variety (HYV) rice. The relatively minor role in cropping systems of these crops despite their higher returns, can largely be attributed to high price risks associated with marketing, suggesting the need for further development of agro-processing industries, rural infrastructure, and marketing networks.

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Quazi Shahabuddin[1] and Paul Dorosh[2]

1. INTRODUCTION

In most developing countries, including Bangladesh, social or economic profitability deviates from private profitability because of distortions in factor and output markets, externalities and government policy interventions that tend to distort relative prices. It is, therefore, necessary to assess the comparative advantage of production of different crops in Bangladesh. It may be emphasized that the analysis of this comparative advantage can help in deriving meaningful policy conclusions on how to reorient the farming system towards more efficient crop activities.

Attainment of self-sufficiency in foodgrains has been an important socio-political objective in Bangladesh.[3] Several studies have shown that attainment of foodgrain self-sufficiency is not only an important socio-political objective; it is eminently sensible as well from a strictly economic point of view. Some of the pertinent questions that can be raised in this context are: should Bangladesh increase rice production beyond self-sufficiency or, conversely, should Bangladesh strive for self-sufficiency if it can increase agricultural growth and farm income by producing more crops other than rice? Designing appropriate public policy with regard to rice hinges upon the answers to such

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[3] Rice constitutes about 90 percent of total foodgrain production. Moreover, wheat production is constrained by adverse agro-climatic factors in the country. Therefore, self-sufficiency in foodgrain production usually means rice self-sufficiency in the context of Bangladesh.

questions hinges upon the answers to such questions. While farmers would decide what to grow based on their own perceptions of potential and constraints, public policies concerning irrigation, water control, technology and prices can influence farmers' crop growing decisions (Ahmed, 2000). A comparative evaluation of producing rice vis-a-vis other crops is therefore required to address the issue of foodgrain self-sufficiency in the country both under the medium and long-term perspectives.

Bangladesh, as a member of the WTO, is committed to the rules and regulations that the Uruguay Round applied to agriculture. The commitments cover a wide range of topics including those in the area of domestic support, market access and export subsidies in agriculture. The potential benefits of the UR Agreements for Bangladesh would emerge from the trading regime in its present form and the potential trading opportunities for both import substitution and export promotion in Bangladesh. However, eventually, whether or not a country can take advantage of the new trading opportunities would depend upon its comparative advantage, without subsidies or with limited subsidies that are permitted for all trading partners by the rules governing the new trading environment. Therefore, an assessment of comparative advantage of crop production either for import substitution or export can be helpful in this respect.

2. METHODOLOGY

In this paper, we use two alternative partial equilibrium measures of economic efficiency to assess comparative advantage of different crops in Bangladesh agriculture: (a) Net Economic Profitability per unit of land and (b) the Domestic Resource Cost ratio. Both of these indicators assess the value of outputs and inputs using economic prices (shadow prices that reflect the scarcity value of these goods and services in the Bangladesh economy). Thus, these measures differ from indicators of private profitability, which assess the values of outputs and inputs using private prices, which are equal to the actual or expected financial (market) prices for goods and services that are bought or sold.

Using the Policy Analysis Matrix (PAM) framework developed by Monke and Pearson (1989), private profits (D) are equal to total revenues (A) less the cost of tradeable inputs (B) and domestic resources such as land, labor and capital (C), all evaluated at private prices (Table 1). Similarly, social profits (H) are defined as total revenues (E) less the cost of tradeable inputs (F) and domestic resources such as land, labor and capital (G), all evaluated at their social opportunity costs (social prices). In this study, because of difficulties evaluating the social opportunity cost of land, we present estimates of net economic profits per unit of land, calculated as revenues less the value of tradeable inputs and domestic resources other than land, all evaluated at social prices, per unit of cropped land.[4]

The estimation of net economic returns per unit of cropland, it may be emphasized, is one way of looking at comparative advantage in terms of efficiency of resource use and land allocation for producing crop or crop mixes. However, in order to meaningfully interpret these estimates as indicators of comparative advantage, it is necessary to know the nature and scope of competition or complementarity in the choice of crops (Mahmud et al., 1993). An attempt is made to address this issue in our exercise in the subsequent section.[5]

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[4] For a detailed discussion on these issues in the context of Bangladesh agriculture, see Mahmud et al. (1994), Morris et al. (1997) and Shahabuddin (1999).

[5] Crop rotations are discussed in more detail in Chapter 5.

Table 1—Policy Analysis Matrix (PAM)

	Revenues	Costs		Profits
		Tradeable Inputs	Domestic Resources	
Private Prices	A	B	C	D
Social Prices	E	F	G	H
Effects of Divergences and Efficient Policy	I	J	K	L

Notes: Private Profits (D) = A - B - C
Social Profits (H) = E - F - G
Output Transfers (I) = A - E
Input Transfers (J) = B - F
Factor Transfers (K) = C - G
Net Transfers (L) = D - H = I - J - K

Ratio indicators for comparison of unlike outputs are:

Private Cost Ratio (PCR) = C/(A - B)
Domestic Resource Cost Ratio (DRC) = G/(E - F)
Nominal Protection Coefficient on Tradeable Output (NPC) = A/E
Nominal Protection Coefficient on Tradeable Input (NPC) = B/F
Effective Protection Coefficient (EPC) = (A - B)/(E - F)
Subsidy Ratio to Producers (SRP) = L/E or (D - H)/E

Source: Monke and Pearson (1989).

DOMESTIC RESOURCE COST RATIO

Although economic profitability provides a measure for assessing the relative efficiency of alternative cropping activities, a comparison of net returns per unit of land area is sometimes complicated by activities that may differ greatly in their intensity of input use. Hence, the information used for the economic profitability analysis is used to calculate domestic resources cost ratios (DRCs) for different crops. DRCs are unit-free ratios that express the efficiency of alternative domestic production activities by indicating the total value of domestic resources required to generate or save a unit of foreign exchange. In terms of the PAM framework, the DRC is equal to domestic resources valued at social prices (G) divided by the difference between the value of output and the value of tradeable inputs evaluated at social prices (E - F).[6]

It may be mentioned here that the net economic benefit per unit of land is likely to be a more appropriate guide for the ranking of crops, compared with that of per unit (or taka) of the domestic resources, which is what the inverse of the DRC coefficient essentially indicates (Scandizzo and Bruce, 1980). However, the estimation of DRCs can be a convenient method of generally assessing the comparative advantage of a single dominant crop by indicating the economic profitability of keeping resources in its production instead of allocating them elsewhere (Anderson and Ahn, 1984).

[6] Note, also, that since the DRC ratio calculations require estimates of the opportunity cost of land, inaccuracies in measuring this opportunity cost can potentially affect crop rankings.

3. NATURE AND SOURCES OF DATA

The empirical exercise involving the estimation of both net financial and economic returns, as well as domestic resources cost ratio requires the following sets of data.

(a) Production Coefficients
(b) Financial Prices of Crops and Production Inputs
(c) Economic (Shadow) Prices of Crops and Production Inputs
(d) Shadow (Equilibrium) Price of Foreign Exchange

PRODUCTION COEFFICIENTS

The estimates of yield and input coefficients of various crops used in this exercise are those used in the IFPRI-BIDS study on Crop Diversification (Mahmud et al., 1993). These, in turn, were based on the information collected in the survey on costs and returns of crop production undertaken for the study earlier (Zohir, 1993). This was a fairly large-scale survey designed to cover the different agro-ecological zones of the country, with a special emphasis on generating information on the relatively minor crops not usually covered in most farm surveys. The crop production activities were distinguished by irrigation technique and/or seed variety.[7] The coefficients expressed at 1990/91 prices were updated to 1997/98 prices using relevant deflators.

FINANCIAL PRICES OF CROPS AND PRODUCTION INPUTS

The net financial returns of different crops have been estimated using the set of financial prices (market prices actually received by farmers for outputs and paid for purchased inputs) during the period under study (1996/97, 1997/98 and 1998/99). The

[7] This information on production coefficients is presented in the Appendix (Table A.1).

harvest prices of various crops were compiled from the Statistical Yearbook published by the BBS for 1996/97. The financial prices for 1997/98 and 1998/99 were collected for this study from the Directorate of Agricultural Marketing, Ministry of Agriculture.

The financial returns were estimated in this exercise on the basis of full-costing of inputs. In other words, both cash-purchased and family-owned inputs were valued at market prices. In particular, the prevailing market wage rates of agricultural labor for 1996/97 years were compiled from various issues of the Monthly Statistical Bulletin published by the Bangladesh Bureau of Statistics. The wage data for 1997/98 and 1998/99 were collected from the Directorate of Agricultural Marketing. The farm level prices (weighted average of monthly prices) of different chemical fertilizers for the 1996/97 period under study were compiled from the Monthly Agricultural Marketing Reports published by ATDP/IFDC. The prices for 1997/98 and 1998/99 were collected from the Directorate of Agricultural Marketing.

Other financial costs incurred in crop production such as irrigation, pesticides, manure, seed/seedling etc. have been taken from the farm survey carried out by Zohir (1993) as mentioned earlier. However, since these costs relate to the survey period of 1990/91, they were subsequently converted to costs for the period under study and expressed at 1997/98 prices using the relevant sectoral deflators.

The financial prices of different crops and various production inputs used in this empirical exercise are presented in the Appendix (Table A.2).

ECONOMIC (SHADOW) PRICES OF CROPS AND PRODUCTION INPUTS

The choice of appropriate economic (shadow) prices for valuation of crop output should depend, in principle, on the assumption regarding whether additional output will be used for export or import substitution or domestic consumption. In practice, however, because of trade restrictions and lack of market integration, it is not often easy to make a clear distinction in this respect. Hence, it is worthwhile to derive profitability estimates under alternative assumptions.[8] Fortunately, however, the choice is quite clear for a number of crops produced in Bangladesh. Among the crops for which only the import parity price is used, in our exercise, as the basis for output valuation (directly or via processed products) are wheat, cotton, sugarcane, oilseeds, pulses and spices (chilies and onion). On the other hand, jute is clearly an export item, while tobacco and vegetables have only limited access to the export market. Nevertheless, the export potential of vegetables deserves serious consideration. Although potatoes are not currently traded, their economic profitability for export has also been examined.

We have estimated import and/or export parity prices for this exercise for a selected number of crops and production inputs for which data were readily available from the latest issue of Global Commodity Markets: A Comprehensive Review and Price Forecast published by the World Bank (July, 1999). These are paddy/rice (both import and export parity), wheat, cotton, sugarcane (sugar) and oilseeds (seeds) for crops, and Urea, TSP and MP for production inputs such as chemical fertilizers. For other crops, especially for minor crops, specific conversion factors estimated earlier by Mahmud et al. (1993) and Shahabuddin and Syed (1998) have been used. Similarly, for major production inputs such as human labor and irrigation, the specific conversion factors estimated earlier by Shahabuddin and Syed (1998) were used.[9] For minor production

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[8] Moreover, for some crops, it may also be useful to assess their potential comparative advantages on the basis of prospective changes in their tradeability status (Mahmud et al, 1993).

[9] The specific conversion factors, being the ratio between financial costs and economic costs have been used to convert financial costs into economic costs. This is required because of distortions in factor and output markets, externalities and government policy interventions that tend to create divergence between financial and economic costs. This is particularly true in case of non-tradeable inputs such as irrigation and labor, esspecially labor in the face of widespread underemployment prevailing in rural Bangladesh.

inputs such as pesticides and manures, the standard conversion factor has been used to convert financial costs into economic costs. The whole set of conversion factors used in this exercise are shown in the Appendix (Tables A.3 and A.4).

SHADOW (EQUILIBRIUM) PRICE OF FOREIGN EXCHANGE

The extent of distortions in the exchange rate caused by trade policies can be measured by comparing the actual exchange rate with the estimated free-trade equilibrium rate. The latter is usually calculated using the so called "elasticity approach" developed by Krueger, Shiff and Valdes (1991) based on the estimates of implicit price elasticities of import demand and export supply. An alternative way of estimating the degree of misalignment (and extent of overvaluation of domestic currency) is through estimation of the standard conversion factor (SCF) following the so-called "tax approach", which uses the trade weights to estimate SCF. Since SCF also represents the ratio of the official exchange rate (OER) to the equilibrium exchange rate (EER), the reciprocal of SCF also indicates the degree of misalignment in foreign currency (or extent of overvaluation of domestic currency) in the economy. Following this approach, the Resident World Bank Mission in Dhaka (1998) estimated the standard conversion factor (SCF) for 1997/98 to be 0.914 and the corresponding shadow exchange rate to be Tk. 49.67.

4. ASSESMENT OF COMPARATIVE ADVANTAGES: RESULTS

The comparative advantage of different crops has been assessed in this exercise, as mentioned earlier, using two indicators: net economic profitability (vis-a-vis net financial profitability) measured in terms of economic (financial) returns per hectare, and domestic resource costs, which indicate the total value of domestic resources required to generate or save a unit of foreign exchange. Both are indicators of relative efficiency in domestic production. They indicate whether the domestic economy has a comparative advantage in producing a particular crop relative to other countries as well as to other crops that could be produced.[10]

The estimates of financial and economic returns per hectare, as well as domestic resource cost ratios for rice crops, are presented in Table 2, while those for non-rice crops are presented in Table 3. It may be noted here that while for a number of crops, the estimates of economic profitability correspond to alternative assumptions regarding their tradability status (import, export or non-tradeable), financial profitability is estimated using only a single set of farmgate prices for the 1996/97 - 1998/99 period.

[10] A country may have a number of efficient production opportunities but in order to maximize economic growth, should pursue those for which it exhibits the strongest comparative advantage i.e. highest net economic returns and/or lowest domestic resource costs (The World Bank, 1992).

Table 2—Financial and Economic Profitability, and Domestic Resource Costs of Rice Crops in Bangladesh: 1996/97 - 1998/99 Period

Rice Crops	Irrigation Technique	Net Financial Return (Tk./hectare)	Net Economic Return (Tk./hectare)			Domestic Resource Cost		
			Import Parity	Non-Traded	Export Parity	Import Parity	Non-Traded	Export Parity
Boro								
HYV	Modern	7299	18172	12047	7254	0.70	0.89	1.12
Local	All	3953	9245	6156	3758	0.93	1.15	1.40
Aman								
HYV	Modern	9782	19682	13741	9090	0.62	0.78	0.96
HYV	Rainfed	11216	20490	14644	10069	0.59	0.74	0.91
HYV	All	10459	19970	14177	9644	0.61	0.75	0.93
Pajam	All	8528	17413	12056	7863	0.67	0.84	1.03
Local T.	Rainfed	4250	10105	6682	4003	1.04	1.28	1.57
Local B.	Rainfed	2735	7374	4686	2583	1.55	1.15	1.40
Aus								
HYV	Rainfed	3831	10638	6751	3710	0.81	1.02	1.27
HYV	Modern	5494	13918	9088	5308	0.73	0.91	1.13
HYV	All	3410	10763	6648	3428	0.82	1.04	1.30
Local B.	Rainfed/ Traditional	-2371	1757	-258	-1834	1.25	1.55	1.91

Source: Author's calculations.
Note: The estimates are average for 1996/97, 1997/98 and 1998/99, expressed at 1997/98 prices.

Table 3—Financial and Economic Profitability, and Domestic Resource Costs of Non-Rice Crops in Bangladesh: 1996/97 - 1998/99 Period

Non-Rice Crops	Irrigation Technique	Net Financial Return (Tk./hectare)	Net Economic Return (Tk./hectare)			Domestic Resource Cost		
			Import Parity	Non-Traded	Export Parity	Import Parity	Non-Traded	Export Parity
Wheat	Modern	2819	6466	-	-	0.90	-	-
Wheat	Non-irrigated	3254	6101	-	-	0.91	-	-
Wheat	All	3165	6540	-	-	0.89	-	-
Jute (White)	Rainfed	751	-	-	8189	-	-	0.92
Jute (Tossa)	All	2804	-	-	11140	-	-	0.80
Cotton	Rainfed	18665	16886	-	-	0.55	-	-
Tobacco	Modern	11391	-	-	92425	-	-	0.20
Tobacco	All	9993	-	-	91212	-	-	0.21
Sugarcane (Sugar)	Modern	44081	33323	-	-	0.81	-	-
Sugarcane (Sugar)	Non-irrigated	25726	18575	-	-	1.11	-	-
Sugarcane (Gur making)	Modern	44081	1455	-	-	1.53	-	-
Sugarcane (Gur making)	Non-irrigated	25726	-5795	-	-	2.14	-	-
Mustard (oil)	Traditional/ Non-irrigated	4235	-2747	-	-	3.20	-	-
Mustard (seed)	Traditional/ Non-irrigated	4235	3576	-	-	1.25	-	-
Sesame (oil)	Traditional/ Non-irrigated	-1361	-6463	-	-	3.90	-	-
Sesame (seed)	Traditional/ Non-irrigated	-1361	-1274	-	-	1.75	-	-
Linseed (oil)	Traditional/ Non-irrigated	3542	-597	-	-	1.91	-	-
Linseed (seed)	Traditional/ Non-irrigated	3542	2885	-	-	0.86	-	-
Masur (Lentil)	Traditional/ Non-irrigated	8521	14543(H) 10358(L)	- -	9715 -	0.43(H) 0.54(L)	- -	0.56 -

Table 3—Financial and Economic Profitability, and Domestic Resource Costs of Non-Rice Crops in Bangladesh: 1996/97 - 1998/99 Period (Cont.)

Non-Rice Crops	Irrigation Technique	Net Financial Return (Tk./hectare)	Net Economic Return (Tk./hectare)			Domestic Resource Cost		
			Import Parity	Non-Traded	Export Parity	Import Parity	Non-Traded	Export Parity
Gram	Traditional/ Non-irrigated	6621	12184(H) 8407(L)	- -	7826 -	0.44(H) 0.55(L)	- -	0.57 -
Khesari	Traditional/Non-irrigated	4538	8551(H) 5867(L)	- -	5454 -	0.62(H) 0.78(L)	- -	0.81 -
Chilli (dry)	Modern	16429	6549	-	-	1.11	-	-
Chilli (dry)	Traditional/ Non-irrigated	3118	-3318	-	-	1.64	-	-
Onion	All	97482	86322	-	-	0.25	-	-
HYV Potato (fresh)	Modern	52636	194815	86760	29130	0.17	0.32	0.61
HYV Potato (fresh)	Rainfed	49036	183469	81229	26701	0.18	0.34	0.63
HYV Potato (fresh)	All	49140	184665	81702	26788	0.18	0.33	0.63
Local Potato (fresh)	All	12388	71876	27573	3944	0.32	0.40	0.56
HYV Potato (chilled)	All	49140	120926	-	-	0.31	0.32	-
Brinjal	Modern	53206	-	-	322014	-	-	0.10
Brinjal	Traditional	39666	-	-	239561	-	-	0.11
Radish	Traditional/ Non-irrigated	13572	-	-	351669	-	-	0.07
Cucumber	Modern/Traditional	26213	-	-	194865	-	-	0.11
Barbati	Traditional/ Non-irrigated	27177	-	-	207248	-	-	0.12
Arum	Traditional/ Non-irrigated	35208	-	-	328966	-	-	0.07
Tomato	Modern/Traditional	93730	-	-	553940	-	-	0.05
Cabbage	Modern/Traditional	42638	-	-	498056	-	-	0.05

Source: Author's calculations.
Note: Same as in Table 1.

PROFITABILITY OF RICE CROPS

The crop activities for rice are distinguished by season, variety, planting method and irrigation techniques. Seasons include aus, aman and boro, seed varieties are either local or high yielding and planting methods distinguish between broadcast and transplanted. Water control options are either rainfed or irrigated, with several different techniques.

The estimates of Table 2 indicate that when compared with financial returns, economic returns at import parity price are considerably higher for all varieties of rice produced using different irrigation techniques. Thus the economic profitability analysis demonstrates that Bangladesh has a comparative advantage in domestic production of rice for import substitution.[11] However, at the export parity price, the picture becomes completely different and the economic returns are now less than the financial returns for almost all varieties of rice. Moving to an export price regime implies a substantial decline in economic profitability for all rice crops. Moreover, when compared with economic profitability estimates of many non-rice crops, it would appear that the country has more profitable options other than production for rice export. Another important consideration here is the likely effect on producers' 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 on a sustained basis. Also, export and import of rice are often proposed as trade-based mechanisms of short-term price stabilization in the face of

[11] These results support the conclusions derived earlier by Mahmud et al. (1993) and more recently, by Shahabuddin (1999) and Ahmed (2000).

fluctuations in domestic production. The question of comparative advantage in rice export, however, is related to a longer-term supply-demand strategy and should be distinguished from short-run considerations for stabilization (Mahmud et al, 1994). Nevertheless, since the results of profitability estimates suggest that a swing between export and import may result in an unacceptable degree of price variation in domestic rice market, this calls for an active policy for management of food stock in the country.

The estimated domestic resource cost ratios for rice are generally consistent with the results of the economic profitability analysis discussed above.[12] With the estimated DRC of rice grown in three seasons (except local varieties of aus and aman) observed to be less than unity under import parity price, the emphasis on attainment of self-sufficiency in rice production appears to be economically justified. On the other hand, the DRC ratios under the export parity price are mostly greater than one (excepting HYV aman) indicating that there is hardly any economic ground of production for export from a strictly efficiency point of view.

It may be mentioned here, however, that a country that is on the verge of self-sufficiency, i.e. requiring imports in certain years visited by natural disasters and producing exportable surplus in others and where the difference between export and import parity prices is large, faces considerable dilemma in its trade policy. Under such circumstances in Bangladesh, a bumper rice harvest will push the domestic rice price to drop to export parity level or even below the export parity levels, without actual exports

[12] Among the additional information needed to calculate DRC, the most important is the estimate of economic value of land. This has been derived in this exercise by adjusting the rental value of land for different crops, as compiled from the 1990/91 field survey by Zohir (1993), by standard conversion factor estimated for the period. Other important adjustments made are: 35% of the (economic) costs of irrigation, 90% of the (economic) costs of draft power, and full (economic) costs of labor and manure have been treated as domestic resources (non-tradeables).

taking place due to a lack of appropriate export infrastructure including a lack of market connections and international processing/grading facilities. Under such a situation, Ahmed (2000) suggests that the challenge is to persevere beyond the critical point to become a small but consistent exporter, even if quantities exported are small. Such an objective would not be economically irrational as long as the opportunities for high-value products are not adversely affected. However, increasing rice production on a sustained basis within the export parity context (i.e. in the context of declining prices) would call for a greater emphasis on technological development than what has been provided in the past.

PROFITABILITY OF NON-RICE CROPS

There is hardly any comparative advantage for Bangladesh to expand area under wheat, barring some unanticipated breakthrough in the development of heat-resistant and better-adapted wheat varieties.[13] Bangladesh should continue to import wheat to meet its growing demand. Although both the financial and economic returns of jute are quite low as compared to most varieties of rice, it appears to have higher economic profitability than local aus, its main competing crop. Moreover, the economic returns (at export parity price) are observed to be much greater than financial returns indicating its comparative advantage in production for export. The profitability estimates for cotton suggest that Bangladesh has a weak comparative advantage in domestic production for import substitution. Although the net economic return is quite high especially as compared with aman rice (cotton is grown during the aman season), it is observed to be less than its

[13] The study by Morris et al. (1994) on wheat production suggests that wheat can compete, both financially and economically, with other winter season crops such as pulses and oilseeds (also non-irrigated boro) but that it cannot compete with HYV boro under irrigated conditions in most areas of the country.

financial return.[14] The profitability estimates for tobacco indicate that while as a dry season irrigated crop it is only modestly profitable in terms of financial returns, the net economic returns are quite high implying strong profitability when exported. The large discrepancy between the financial and economic returns can be attributed to very high profits earned by exporters having limited access to foreign markets.

There is hardly any comparative advantage in producing sugarcane for sugar milling, given the current state of milling efficiency. Sugarcane, however, displays very strong financial profitability resulting from the high protection provided to the domestic sugar industry. The profitability estimates also indicate that even for gur-making, sugarcane production appears to generate negative economic returns under non-irrigated conditions (which represent the dominant mode of cultivation) and the economic return is very low even with higher yields obtained under modern irrigation.[15]

The profitability estimates show negative economic returns when import substitution of edible oil is concerned. However, the economic returns are mildly positive (except sesame) when import substitution of oilseeds is considered. The former is due to heavy protection provided to both oilseeds and edible oil in Bangladesh, while the latter can be attributed to the inefficiency of the local oil-milling industry in the country. An implication of this is that the country would be better off by directly importing edible oil rather than by processing the imported oilseeds.

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[14] This should be attributed to a steady decline in world price of raw cotton over the last decade – from $ 1819/ton in 1990 to $ 1748/ton in 1997 and further to $ 1445/ton in 1998. The projected world prices also indicate a decline over the next ten years till 2010 (The World Bank, 1999).

[15] When compared with other crops such as rice, sugarcane is shown to have a high net profit in both financial and economic terms and therefore, have a high comparative advantage. However, it should be recognized that sugarcane is a crop which takes a year for growth and within the year, one could raise two rice crops instead of one sugarcane crop. Therefore, the net profits for sugar cane should be compared with sequences of two (or more) crops that can be grown on similar land types.

Unlike oilseeds, pulses (specially, masur) appear to be quite competitive as a non-irrigated rabi crop in terms of both financial and economic profitability. The economic returns (under both import and export parity prices) are greater than the corresponding financial returns indicating that they have a comparative advantage in production not only for import substitution, but export as well. It should be recognized, however, that pulses have traditionally been grown in dryland soils during seasonal intervals, which do not compete with HYV boro rice, because profits though reasonably high for a non-irrigated rabi crop, are much lower than high-yielding varieties of rice. This is why although domestic prices are 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.

Chillies and onions are the two of the most important spices in the country. Chillies display negative economic profitability when produced under traditional/non-irrigated conditions, and the economic returns, though positive, are much lower than the financial returns when produced using modern irrigation.[16] Onions, on the other hand, show not only high financial returns but also strong comparative advantage for import substitution as well.

Vegetables appear to be highly competitive in terms of both financial and economic returns. All types of vegetables considered in this exercise (except radishes) have highly favorable financial returns when compared with rice, even those of high yielding varieties. One would, therefore, expect these products to be better represented in the production pattern currently prevalent in the country. That this is not so may have to do with greater perishability and higher price variability of vegetables in the country. The economic profitability of vegetable production for export appears to be fabulously

[16] In fact, because of high domestic prices, the financial returns are quite high, especially when produced under modern irrigation, thereby retaining its competitive edge from a financial point of view.

high as compared with most other crops. However, these exports are constrained by lack of experience with these crops in Bangladesh as well as a variety of marketing problems including product quality, acceptable packaging, high transport costs and market access.[17]

The financial profitability of potato (both fresh as well as chilled potato, except the local variety) appears to be very high, similar to other items in the vegetables category except radishes. The estimated economic returns under both import and export parity prices indicate that the production of the modern variety of potato has a strong comparative advantage for import substitution, but not for export, although some export possibilities perhaps cannot be ruled out.

The estimated domestic resource costs (DRC) of wheat are observed to be lower than unity under different irrigation conditions thereby demonstrating the crop's efficiency of domestic production. However, as compared to high yielding varieties of rice, the ratios are observed to be higher implying that resources can be used more efficiently in the cultivation of modern varieties of rice under irrigated conditions.[18] The DRC ratios for jute (0.80-0.92), though less than unity, are quite high relative to most other crops indicating its comparative advantage for export but at the same time, there may be some competing demand on resources for production of other crops from an efficiency point of view. The estimated DRC ratio for cotton (0.55) indicates its relative efficiency of domestic production for import substitution, especially during the aman season when it is produced. The relative efficiency of production for export of tobacco is

[17] For an elaborate discussion of and detailed analysis on these constraints, see Islam (1990) and Ahmed (2000).

[18] In a recent study, Morris et al (1997), have estimated the DRC ratios for wheat and its competing crops, under both irrigated and non-irrigated conditions. It has been shown that in irrigated plots, boro rice production is most efficient in most of the zones (northwest, northeast and southwest zones), except in the southcentral zone, where wheat production is most efficient. In non-irrigated plots, where production of irrigated boro and wheat are not feasible, wheat production represents the most efficient use of domestic resources in all zones, except the northeast where oilseeds dominate.

observed to be quite pronounced as reflected in its very low DRC ratio estimates (0.20 - 0.21).

Sugarcane, on the other hand, hardly displays any comparative advantage in terms of efficiency in domestic production for import substitution, with estimated DRC ratios exceeding unity in almost all cases. This is largely attributed, as mentioned earlier, to the excessive milling costs incurred by inefficient sugar refineries under public ownership. The situation is even bleaker in the case of production of oilseeds for import substitution, considered either in terms of import of oil or of seeds. The estimated DRC ratios are observed to exceed unity by a large margin in most cases. This again can, at least, partly be attributed to the inefficiency of the local oil-milling industry.

The estimated DRC ratios of different types of pulses are observed to be less than one in all cases thereby demonstrating their efficiency in domestic production not only for import substitution but export as well, although the relative efficiency is observed to be less in case of the latter as compared to the former. Among the three types of pulses, khesari performs worse than the other two, masur and gram. Of the two types of spices considered in this exercise, the production of dry chillies does not appear to be efficient under either modern irrigation or traditional/non-irrigated conditions, with DRC ratios exceeding unity in both cases. Onion, on the other hand, is observed to be highly efficient in production for import substitution, as reflected in its low estimate of DRC ratio (0.25).

The production of potato, under both modern and traditional irrigation, seems to be highly efficient for both import substitution and export -- more for import substitution than for export -- the estimated DRC ratios being higher for the latter than for the former. The production of different types of vegetables considered in this exercise would appear to be highly efficient, especially for export as reflected in the extremely low estimates of DRC ratios of these crops (0.05 - 0.12).

SENSITIVITY ANALYSIS

It may be worthwhile to examine the degree to which the efficiency measures estimated under the set of baseline assumptions are likely to be affected by changes in the values of key parameters. In fact, sensitivity analysis is warranted for two main reasons (Morris et al, 1997). First, the profitability analysis is based on certain simplifying assumptions regarding production technologies as reflected in the input-output coefficients, market conditions, prices (both financial and economic prices), government policies etc. Since the values used for these parameters obviously affect the analysis, it is important to know the extent to which the empirical results are sensitive to the simplifying assumptions that were made. Second, the efficiency rankings produced by the DRC framework are static in the sense that they represent a snapshot taken at a fixed point of time, whereas actual efficiency rankings are dynamic in the sense that they can, and do, change in response to changes in resource endowments, production technology, market conditions and government policies. Therefore, it is important to ascertain whether the results are likely to be affected by probable future changes in any of these basic parameters.

Effect on Financial Profitability

The figures in Table 4 show that net financial returns are quite sensitive to changes in yield of different crops. This is especially true in the case of wheat, jute, mustard and different varieties of rice considered in this exercise.[19] The same is true for

[19] For example, a 10% increase in yield results in a 65% increase in the net financial returns of wheat, 62% of jute, 34% of mustard and between 26-38% of different varieties of rice.

variation in price as well. The changes in the cost of irrigation, on the other hand, have a marginal impact on net financial returns of different crops.[20] The changes in money wage rate have a differential impact for different crops. The impact is quite pronounced in the case of jute, wheat, mustard and different varieties of rice, but somewhat marginal in the case of other crops, namely, cotton, masur, sugarcane and tomato.[21] This can largely be attributed to the differences in the intensity of labor use for different crops considered in our exercise.

Table 4—Effect on Financial Profitability Due to Changes in Yield, Price, Cost of Irrigation and Wage Rate for Selected Crops in Bangladesh

(Tk/hectare)

Crops	Base Case	Changes in Yield		Changes in Price		Changes in Irrigation Cost		Changes in Wage Rate	
		- 10%	+ 10%	- 20%	+ 20%	- 20%	+ 20%	- 10%	+ 10%
HYV Boro	7299	4634	9960	1971	12623	8032	6561	10188	6257
HYV Aman	9782	7199	12336	4616	14949	9836	9729	10911	8654
HYV Aus	5494	3394	7595	1294	9695	5610	5329	6555	4434
LT Aman	4250	2762	5738	1274	7226	4255	4244	5090	3410
Wheat	2817	993	4644	-832	6469	3106	2531	3653	1984
Jute (Tosha)	2804	1068	4539	-667	6274	2863	2774	4094	1513
Cotton	18665	15175	22155	11685	25645	18685	18646	19773	17558
Sugarcane	44081	36493	51668	28906	59255	44166	43995	45750	42411
Mustard	4235	2798	5672	1361	7109	-	-	4854	3616
Masur (Lentil)	8521	6912	10131	5302	11741	8530	8513	8952	8091
HYV Potato	52639	42345	62927	32054	73218	52952	52319	54205	51066
Tomato	93730	81658	105802	69586	117874	93845	93615	95473	91987

Source: Author's Calculations

[20] For example, a 20% increase in irrigation cost leads to a decline in the net financial return of around 10% in case of boro rice, wheat, masur and tomato. For other crops, the impact is mostly negligible (less than 1%).

[21] For example, a 10% increase in the money wage rate leads to a decline in net financial returns of 46% for jute, 30% for wheat, 15% for mustard and between 12-20% for different varieties of rice, but only 6% for cotton, 5% for masur, 4% for sugarcane, 3% for potato and 2% for tomato.

Effect of Changes in Output Prices (Economic) on Efficiency in Domestic Production

The effect of changes in potential output prices (economic) on efficiency in domestic production of rice, as reflected in the estimated DRC, has been captured through changes in the international reference price on which the parity price calculations are based. The results are presented in Tables 5A and 5B, for import and export parity prices, respectively.

Table 5A indicates that the estimated DRCs of different varieties of rice grown in various seasons are fairly sensitive to changes in the international (reference) price of rice used in the calculation of import parity prices. An increase in international price by $20/ton would make the domestic production of LT Aman economically efficient for import substitution, with a DRC value of less than unity.[22] Table 5B indicates that the estimated DRCs are more sensitive to changes in international price when domestic production is considered for export. An increase in international price by $35 would make the domestic production of both HYV boro and HYV aus economically efficient for export as well.

Table 5A—Variation in Domestic Resource Cost (DRC) Due to Changes in Economic Price of Rice

Economic Price (Import Parity)	Domestic Resource Cost (DRC)			
	HYV Boro	HYV Aman	HYV Aus	LT Aman
Tk. 8.00/kg ($ 260/ton)	0.80	0.71	0.83	1.18
Tk. 8.34/kg ($ 280/ton)	0.76	0.68	0.79	1.12
Tk. 8.97/kg[a] ($ 300/ton)	<u>0.70</u>	<u>0.62</u>	<u>0.73</u>	<u>1.04</u>
Tk. 9.38/kg ($ 320/ton)	0.66	0.59	0.69	0.99
Tk. 9.73/kg ($ 335/ton)	0.63	0.57	0.66	0.96

Source: Author's calculations.
Note: [a] denotes value used in the base scenario.

[22] The domestic production of LT Aman is now economically efficient in the sense that it would consume less domestic resources than it would generate net value added to tradeable goods and services.

Table 5B—Variation in Domestic Resource Cost (DRC) Due to Changes in Economic Price of Rice

Economic Price (Export Parity)	Domestic Resource Cost (DRC)			
	HYV Boro	HYV Aman	HYV Aus	LT Aman
Tk. 5.12/kg ($ 260/ton)	1.39	1.16	1.38	1.87
Tk. 5.56/kg ($ 280/ton)	1.27	1.07	1.27	1.74
Tk. 6.13/kg[a] ($ 300/ton)	1.12	0.96	1.13	1.57
Tk. 6.60/kg ($ 320/ton)	1.02	0.88	1.03	1.44
Tk. 6.95/kg ($ 335/ton)	0.95	0.83	0.97	1.37

Source: Author's calculations.
Note: [a] denotes value used in the base scenario.

Table 6—Variation in Economic Profitability and Domestic Resource Cost Ratio Due to Changes in Economic Price of Wheat

Economic Price (Import Parity)	Net Economic Return (Tk/hectare)	Domestic Resource Cost
Tk. 7.25/kg ($ 110/ton)	3363	1.11
Tk. 7.65/kg ($ 120/ton)	4275	1.04
Tk. 8.63/kg[a] ($ 146/ton)	6466	0.90
Tk. 9.25/kg ($ 160/ton)	7926	0.82
Tk. 9.66/kg ($ 170/ton)	8838	0.78

Source: Author's calculations.
Note: [a] denotes value used in the base scenario.

It is observed from Table 6 that the estimated DRCs are quite sensitive to changes in the international price of wheat. In fact, a decrease in the international price by $26 would make the domestic production of wheat economically inefficient for import substitution, while an increase in price by $24 would make it comparable (in terms of relative efficiency in domestic production) to high-yielding varieties of rice. Price changes of such magnitude have been experienced in the international wheat market in recent years.[23] The economic profitability of wheat, as reflected in the estimated net

[23] In fact, the f.o.b. price of US GULF HRW wheat has increased to around $160/ton, while the f.o.b. price of 5% broken Thai rice has decreased to about $240/ton in recent times.

economic return, is also found to be highly sensitive to changes in the international price and hence import parity price of wheat.[24]

Table 7—Effect on Domestic Resource Cost Ratios of Changes in Shadow Wage Rates

Wage Rate Conversion Factors	Domestic Resource Cost Ratio (DRC)				
	HYV Boro	HYV Aman	HYV Aus	LT Aman	Wheat
0.50	0.58	0.50	0.58	0.89	0.73
	(0.94)	(0.77)	(0.91)	(1.34)	(-)
0.65	0.63	0.55	0.65	0.95	0.80
	(1.02)	(0.85)	(1.00)	(1.44)	(-)
0.75	0.66	0.59	0.69	1.00	0.85
	(1.07)	(0.91)	(1.07)	(1.51)	(-)
0.80	0.68	0.61	0.71	1.02	0.87
	(1.10)	(0.93)	(1.10)	(1.54)	(-)
0.85[a]	0.70	0.62	0.73	1.04	0.90
	(1.12)	(0.96)	(1.13)	(1.57)	(-)
0.90	0.71	(0.64)	0.75	1.06	0.92
	(1.15)	(0.99)	(1.17)	(1.60)	(-)
0.95	0.73	0.66	0.77	1.08	0.94
	(1.18)	(1.01)	(1.20)	(1.63)	(-)
1.00	0.75	0.68	0.79	1.11	0.97
	(1.20)	(1.04)	(1.23)	(1.67)	(-)

Note: [a] denotes value used in the baseline scenario. Figures in parentheses represent value of DRC based on export parity price.
Source:Authors' calculations.

Effect of Changes in Input Prices on Efficiency in Domestic Production

Sensitivity analysis has been carried out to determine whether the results obtained under the baseline assumption are likely to change as a result of possible future changes in the economic price of one the major inputs, namely human labor used in the cultivation of various crops.[25] Since many of the crop production technologies currently in use are

[24] For example, an increase in the international price by 16% (from $146/ton to $170/ton) leads to an increase in net economic returns of wheat by 37% (from Tk. 6466/ha to Tk. 8838/ha).

[25] Although irrigation is one of the major inputs, especially for irrigated crops, the effect of changes in economic costs of irrigation has not been considered in our exercise, because the changes in costs of irrigation were observed earlier to have only a marginal impact on net financial returns of different crops, including irrigated crops.

quite labor intensive, the cost of labor is likely to have a considerable influence on production efficiency. Table 7 shows how the DRCs of the five crops (four varieties of rice grown in three seasons and wheat) are affected by changes in costs of labor. The estimated DRC values in Table 7 have been derived by using higher and lower values for the wage rate conversion factors needed to convert market wage rates into shadow wage rates. Changes in the conversion factor directly affect the shadow wage rate and thus reveal the effects of possible changes in the opportunity costs as well as future labor supply and demand conditions on the efficiency of each crop. They also indicate the degree to which any possible error in estimating shadow wage rates is likely to affect the results of the DRC analysis (Morris et al, 1993).

The results presented in Table 7 indicate that the estimated DRCs of rice and wheat crops are mildly sensitive to changes in shadow wage rates. As the wage rate conversion factors are decreased, thereby effectively lowering the shadow wage rates, DRCs are observed to decrease for all crops, although not by much.[26] There is not much variation in this respect across different crops considered in our exercise, either. Only in the case of LT Aman, the changes make a perceptible impact in the sense that the domestic production for import substitution now becomes economically efficient.

Effect of Changes in Shadow Exchange Rate

The shadow exchange rate was varied through changes in the exchange rate adjustment factors in order to ascertain the extent to which either any possible error in estimating the shadow exchange rate or any probable devaluation in official exchange rate of domestic currency to correct for its overvaluation is likely to affect the results of

[26] For example, a decrease in wage rate conversion factors from the base case of 0.85 to 0.50 results in a decline of DRC, in case of HYV Boro, from 0.70 (1.12) to 0.58 (0.94), in case of HYV Aman, from 0.62 (0.96) to 0.50 (0.77), in case of HYV aus, from 0.73 (1.13) to 0.58 (0.91), in case of LT Aman, from 1.04 (1.57) to 0.89 (1.34) and finally, in case of wheat, from 0.90 to 0.73 only.

the analysis. Table 8 shows how the DRCs of four rice crops grown in different seasons and also of wheat are affected by the changes in the shadow exchange rates. It is observed that the estimated DRCs are fairly sensitive to changes in the shadow exchange rate – more than what we observed in case of shadow wage rate. This is true for all five crops considered in our exercise with hardly any variation among them.[27] As a result, the efficiency rankings across five crops remain unchanged.

Table 8—Effect on Domestic Resource Cost Ratios of Changes in the Shadow Exchange Rate

Exchange Rate Adjustment Factor	Domestic Resource Cost Ratio (DRC)				
	HYV Boro	HYV Aman	HYV Aus	LT Aman	Wheat
1.00	0.77	0.69	0.81	1.15	1.00
	(1.25)	(1.07)	(1.26)	(1.74)	(-)
0.95	0.73	0.65	0.76	1.09	0.94
	(1.17)	(1.00)	(1.19)	(1.64)	(-)
0.91[a]	0.70	0.62	0.73	1.04	0.90
	(1.12)	(0.96)	(1.13)	(1.57)	(-)
0.85	0.64	0.57	0.67	0.96	0.82
	(1.03)	(0.88)	(1.04)	(1.44)	(-)
0.80	0.60	0.54	0.62	0.90	0.76
	(0.96)	(0.82)	(0.97)	(1.35)	(-)

Source: Authors' calculations.
Note: [a] denotes value used in the baseline scenario to reflect estimated 9 percent overvaluation of the Taka. Figures in parentheses represent values of DRC based on export parity price.

Effect of Future Changes in Production Technology

The production efficiency of different crops could be improved by changes in production technology affecting their yields. Experimental results from different crop research centers suggest that crop yields in farmers' fields could be raised considerably even using currently available technologies. The most promising of these involve an

[27] For example, an increase in exchange rate adjustment factor (thereby lowering the shadow exchange rate) from 0.91 to 1.00 leads to an increase in the estimated DRC, in case of HYV Boro, from 0.70 (1.12) to 0.77 (1.25), in case of HYV Aman, from 0.62 (0.96) to 0.69 (1.07), in case of HYV Aus, from 0.73 (1.13) to 0.81 (1.26), in case of LT Aman, from 1.04 (1.57) to 1.15 (1.74) and finally, in case of Wheat, from 0.90 to 1.00.

increase in the level of use of quality seeds and chemical fertilizers, as well as an improvement in management practices such as land preparation and on-farm irrigation management. The so-called "yield gap" is currently quite large.[28]

The estimated DRCs, as shown in Table 9, indicate that these are quite sensitive to the changes in yield of five different crops considered in our exercise. A 15% increase in yield results in an almost equivalent decrease in the value of DRCs, thereby contributing to enhanced production efficiency for all these crops. This becomes more evident in the case of LT Aman in the sense that the domestic production for import substitution becomes economically efficient now (with 15% increase in yield).[29] The picture remains similar when one considers the DRCs based on export parity prices, with the exception that now HYV Boro and HYV aus enjoy a comparative advantage in domestic production for export as well. A decrease in yield leads to a lowering of production efficiency as reflected in the higher values of estimated DRCs for all five crops. The effect becomes more pronounced in the case of wheat in the sense that its domestic production for import substitution becomes economically inefficient now (with 15% decrease in yield).

The estimated net economic returns are observed to be highly sensitive to changes in the yields of the five crops considered in our exercise (Table 10). The changes are similar to those observed with respect to net financial returns for these crops observed earlier (Table 4) so that their relative positions (net *economic* returns vis-a-vis net *financial* returns) remain unchanged.[30]

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[28] The yield gap between the national average and the experimental station yield for rice is quite large, about 40 percent (Ahmed, 2000). The equivalent yield gap of wheat is much larger, in both absolute and percentage terms (Morris et al, 1993).

[29] An increase in yield of this magnitude is considered feasible even using available technologies but with improved management practices.

[30] For example, a 10% increase in yield of HYV Boro leads to an increase in net financial returns by Tk. 2661/ha (from Tk. 7299/ha to Tk. 9960/ha) and in net economic returns by Tk. 3435/ha (from Tk. 18172/ha to Tk. 21607/ha).

Table 9—Effect on Domestic Resource Cost Ratios Due to Changes in Yield

Changes in Yield	Domestic Resource Cost Ratio (DRC)				
	HYV Boro	HYV Aman	HYV Aus	LT Aman	Wheat
+ 15%	0.59	0.54	0.62	0.90	0.76
	(0.94)	(0.82)	(0.96)	(1.35)	(-)
+ 10%	0.62	0.54	0.65	0.94	0.80
	(0.99)	(0.86)	(1.01)	(1.41)	(-)
+ 5%	0.66	0.59	0.69	0.99	0.85
	(1.05)	(0.91)	(1.07)	(1.49)	(-)
Base Scenario	0.70	0.62	0.73	1.04	0.90
	(1.12)	(0.96)	(1.13)	(1.57)	(-)
- 5%	0.74	0.66	0.77	1.10	0.95
	(1.20)	(1.02)	(1.21)	(1.66)	(-)
- 10%	0.79	0.70	0.82	1.16	1.02
	(1.29)	(1.08)	(1.29)	(1.76)	(-)
- 15%	0.85	0.75	0.88	1.24	1.09
	(1.40)	(1.16)	(1.38)	(1.87)	(-)

Note: Figures in parentheses represent values of DRC based on export parity price.
Source: Authors' calculations.

Table 10—Effect on Economic Returns Due to Changes in Yield

Changes in Yield	Net Economic Return (Tk./hectare)				
	HYV Boro	HYV Aman	HYV Aus	LT Aman	Wheat
+ 15%	23324	24681	17982	12984	9395
	(10769)	(12501)	(8080)	(5967)	(-)
+ 10%	21607	23015	16627	12024	8419
	(9597)	(11364)	(7156)	(5313)	(-)
+ 5%	19889	21349	15273	11064	7442
	(8426)	(10227)	(6232)	(4658)	(-)
Base Scenario	18172	19682	13918	10105	6466
	(7254)	(9090)	(5308)	(4003)	(-)
- 5%	16454	18016	12564	9145	5489
	(6082)	(7954)	(4384)	(3348)	(-)
- 10%	14737	16350	11209	8185	4513
	(4911)	(6817)	(3460)	(2694)	(-)
- 15%	13109	14683	9854	7225	3536
	(3739)	(5680)	(2536)	(2039)	(-)

Note: Figures in parentheses represent values of Net Economic Returns based on export parity price.
Source: Authors' calculations.

5. COMPARATIVE ADVANTAGE OF ALTERNATIVE CROP SEQUENCES

As mentioned earlier, the estimation of net economic returns per unit of cropland of different crops is one way of analyzing comparative advantage in terms of efficiency of resource use and land allocation for production of different crops and crop mixes. However, in order to interpret meaningfully these estimates as an indicator of comparative advantage, it may be worthwhile to estimate the net returns of alternative cropping pattern and/or crop sequence in order to highlight the nature and scope of competition or complimentarity in the choice of crops.

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.[31] 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 and land types. Table 11 presents evidence on such variations in cropping patterns, based on data from a fairly representative nationwide survey.[32] It may be worthwhile to look at the salient features of these cropping patterns.

- Irrigation seems to have a favorable impact on annual cropping intensity on high and medium-high land but negative impact in the case of lower lands.
- The higher the land, the larger the share of land devoted to non-cereal crops within any of the irrigation categories.
- Among all flood-depth levels/land types, the proportion of land allocated to non-cereal crops is considerably lower under irrigated conditions than under rainfed conditions.

[31] 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 characterised by the degree of seasonal flooding, the timing and quantity of rainfall and the soil characteristics. 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 (Mahmud et al, 1994).

[32] The farm survey was conducted in 1987 by BIDS in connection with a study on adoption of HYV rice technology in Bangladesh agriculture.

- However, there is significant difference in the cropping patterns between modern and traditional irrigation, the latter being more conducive to diversified cropping patterns.

The above findings generally support the common view regarding potential cropping patterns on different land types. 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.[33] The currently practiced cropping patterns, it appears, offer little scope for crop diversification through expansion of modern irrigation. It is not surprising that the prospects for crop diversification are often sought in a more intensive cultivation of non-irrigated land. But there may not be much scope for this left as would appear from the recent trends in cropping intensities, especially with respect to dry-season non-irrigated crops. The prospects for intensified cultivation of non-cereal crops through the expansion of area under traditional irrigation also do not seem to be promising. However, there is considerable scope for increasing the yields of non-cereal crops through better farm practices and varietal improvements even under non-irrigated or semi-irrigated conditions. Such yield improvements, rather than more intensive cultivation of land, perhaps offer better growth prospects for these crops (Mahmud et. al., 1994).

The physical environment of production (such as flood depths, rainfall, soil characteristics etc.) certainly constitutes one of the major determinants of production options and crop choices open to farmers. However, incentives for production, as reflected in the net financial and economic returns per unit of crop land, also dictate the choice of cropping patterns in different types of land and irrigation conditions. It is, therefore, worthwhile to compare the net returns (both financial and economic) associated

[33] For a more elaborate discussion on this, see Mahmud et. al. (1994).

Table 11—Crop Areas as Percentage of Net Cultivated Land, by Land Type, 1987

Crop	High Land			Medium-High Land		
	No Irrigation	Traditional Irrigation	Modern Irrigation	No Irrigation	Traditional Irrigation	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) of which:	156	218	180	179	200	194
All rice	85	128	137	128	135	172
All cereals	87	170	153	133	158	177
Non-cereals	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 11—Crop Areas as Percentage of Net Cultivated Land, by Land Type, 1987 (Continued)

Crop	Medium – Low Land			Low Land			
	No Irrigation	Traditional Irrigation	Modern Irrigation	No Irrigation	Traditional Irrigation	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) of which:	191	138	165	165	100	120	173
All rice	140	86	142	121	100	114	126
All cereals	145	105	148	127	100	114	132
Non-cereals	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: Mahmud et al. (1994).

with the cropping patterns across different land types and irrigation conditions. These are presented in Table 12.

It is readily observed from Table 12 that the nature of cropping patterns and the associated cropping intensity is generally reflected in the estimated net financial returns of different land types and irrigation conditions. Net financial returns are generally greater in higher, i.e. high and medium-high, land as compared to those in lower, i.e. medium-low and low, lands. Within each land type, net financial returns are generally observed to be lower for non-irrigated land, as compared to irrigated (both traditional and modern) land. This is largely a reflection of lower cropping intensity and the lower incidence of relatively high-value crops under non-irrigated conditions. Returns to land are observed to be higher under modern irrigation as compared to land irrigated by traditional means for all land types, except in low lands. The difference is most pronounced in the case of medium-high land, despite similar cropping intensity. This can be attributed to the high incidence of local aus (with negative net financial returns per hectare) and the lower incidence of both modern aman and modern boro (with relatively higher net financial returns per hectare) under traditional irrigation (Table 11).

The return to land by land types and irrigation conditions follows roughly the same pattern if the calculations are based on economic prices (i.e. net economic returns per hectare), although in absolute terms the net economic returns (at import parity prices) are much higher as compared to those based on financial prices (i.e. net financial return per hectare). This is not surprising in view of the fact that Bangladesh has a comparative advantage in the production of most crops for import substitution (in the sense that net economic returns for most crops at import parity prices are much higher than their net financial returns) as we observed earlier (Tables 2 and 3).

Table 12—Estimated Net Financial and Economic Returns of Different Land Types and Irrigation Conditions

(Tk/hectare)

	High Land			Medium-High Land			Medium-Low Land			Low Land		
	No Irrigation	Traditional Irrigation	Modern Irrigation	No Irrigation	Traditional Irrigation	Modern Irrigation	No Irrigation	Traditional Irrigation	Modern Irrigation	No Irrigation	Traditional Irrigation	Modern Irrigation
Net Financial Return (Tk/ha)	7958	12535	13117	8092	7342	11856	5514	6854	8638	2963	6907	7858
Net Economic Return (Tk/ha)	33853	60067	31994	24712	31930	28562	18813	21517	20637	13451	17153	18897
Import Parity	25419	40045	16261	10722	21097	11869	8519	9135	8803	6146	6846	7607
Export Parity												
Cropping Intensity (%)	121	206	179	178	190	193	190	136	160	165	100	160

Source: Based on information in Tables 2, 3 and 11 and authors' calculation.

Note: Net returns (both financial as well as economic returns) on a per hectare basis have been computed as weighted average of net financial/economic returns per hectare of different crops, using their percentage share of net cultivated land by land type and irrigation conditions (Table 11, excepting orchards and other crops for which crop-specific net returns were not available), as weights.

However, the net economic returns, unlike net financial returns, are generally observed to be greater under traditional irrigation as compared to those under modern irrigation. This is most pronounced in the case of cultivation in high land, which can be attributed to the greater incidence of high-value crops, under traditional irrigation, whose economic returns are much higher than their financial returns, especially for vegetables. As expected, the estimated net economic returns for all land types and irrigation conditions at export parity prices are much lower than those calculated using import parity prices. However, these estimates become quite comparable to those estimated using financial prices, especially for lower lands thereby losing much of their competitive edge when produced for export market.

These observations, with respect to net returns for different land types and irrigation conditions, need to be qualified in at least two respects. First, the cropping pattern and the associated cropping intensity are based on the field survey carried out in 1987, and therefore, on the land types and irrigation conditions prevailing during that period.[34] Since then, the investments in water control structures and in modern irrigation have resulted in changes in flood depths/land types and considerable growth in irrigated land, which would affect the cropping pattern and/or intensity with concomitant changes in net returns for different land use.[35] Secondly, the crop-specific net returns are based

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[34] The percentage of high, medium-high, medium-low and low land in total land are recorded to be 27.8, 41.7, 21.0 and 9.5 respectively in the 1987 field survey. In other words, the share of high and medium-high land dominates with a combined share of roughly 70% of total land in the country. This compares quite favorably with the estimates of land types based on flood depth (72%) made by M.P.O. earlier (1986).

[35] For example, a recent resurvey of 16 of the 62 villages that belonged to the "flood-prone" ecosystem shows that while the major cropping pattern in the eco-system was the triple-cropped mixed aus-aman rice followed by a non-rice (pulses or oilseed) or a double-cropped aus-aman system, these cropping patterns have almost disappeared now in favor of the single-cropped boro rice, thereby reducing cropping intensity substantially – from 174 in 1987 to 143 percent in 2000. In 1999-2000, nearly 46 percent of the cultivated area was under the single cropped rice system compared to 32 percent in 1987-88 (Hossain et al., 2001). It appears that there is further potential for increase in the area under rice cultivation, if scientists can develop shorter duration boro and transplanted aman varieties, so that farmers can grow two short maturity high-yielding varieties keeping the land follow during the months of heavy flooding (Dey et al., 1995).

on the cost-price configurations prevailing during the late nineties. Any relative changes in such configurations across different crops are likely to affect their net returns and hence the returns to year-round land use of different land types and irrigation conditions estimated in this study.

The nature of competition and/or complementarity in the choice of crops in different land types is not fully reflected in the above analysis with cropping patterns shown in Table 11. Although most non-rice crops compete for land in the dry boro season, the substitution among dry-season crops may entail changes in other seasons as well. It may, therefore, be more useful to look at different crop sequences in various seasons round-the-year associated with various competing crops. Table 13 presents such information, showing the observed/existing crop sequences in three seasons – Rabi, Kharif I and Kharif II (along with percentages of land devoted to such crop sequences) in 10 selected thanas in 4 (new) districts in northwest Bangladesh.[36] Some salient features of physical characteristics of this region may be in order before analyzing the crop sequences, their incidence and associated net returns from land use.

The northwest region is endowed with a favorable land topography, soil and climate for growing multiple crops. High and medium-high lands are the dominant land types with a share of 27% and 54% respectively of total land in 10 selected thanas. The rest of the land is either medium-low land (15%) or low land (4%). Of course, there are variations of land types across the 10 thanas. Cropping intensity averages about 200% in all selected 10 thanas (ranging between 161% in Gangachara thana in Rangpur district to 220% in Sadar thana in Bogra district), while the national average is about 175%. In 10 selected thanas, the single cropped land averages about 18%, double cropped land 58%

[36] In fact, the information is compiled from the study on Northwest Region Integrated Agricultural Development Project Identification carried out by Razzaque (September, 1998).

Table 13—Important Crop Sequences in the Northwest Region

Place		Season			Land Area	% of Total Land
District	Thana	Rabi	Kharif I	Kharif II		
Bogra	Sadar	Boro	-	T. Aman	29000	66.0%
Bogra	Sadar	Potato	Boro	T. Aman	1924	5.0%
Bogra	Sadar	Boro	G.M.	T. Aman	1000	2.0%
Bogra	Sadar	Vegetables	Vegetables	-	1200	3.4%
Bogra	Sherpur	Boro	Fallow	T. Aman	16300	78.0%
Bogra	Sherpur	Boro	Fallow	Fallow	915	5.0%
Bogra	Sherpur	Potato	Boro	T. Aman	640	3.5%
Bogra	Sherpur	Mustard	Boro	T. Aman	549	3.0%
Bogra	Sherpur	Boro	T. Aus	T. Aman	360	2.0%
Bogra	Shibganj	Potato	Boro	T. Aman	4100	16.0%
Bogra	Shibganj	Mustard	Jute	T. Aman	500	2.0%
Bogra	Shibganj	Wheat	Fallow	T. Aman	540	2.0%
Bogra	Shibganj	Boro	Fallow	Fallow	800	3.0%
Bogra	Shibganj	Vegetable	-	Vegetable	600	2.5%
Bogra	Shibganj	Banana	-	Banana	560	2.3%
Rangpur	Gangachara	Tobacco	T. Aus	T. Aman	4800	26.0%
Rangpur	Gangachara	Tobacco	Fallow	T. Aman	4500	24.0%
Rangpur	Gangachara	Boro	Fallow	T. Aman	4000	21.0%
Rangpur	Gangachara	Vegetable	Spices	Spices/Fallow	2500	13.0%
Rangpur	Gangachara	Potato	Jute	T. Aman	1200	6.0%
Rangpur	Gangachara	Wheat	T. Aus	T. Aman	1100	6.0%
Rangpur	Gangachara	Boro Seed bed	Vegetable	T. Aman	700	4.0%
Rangpur	Mithapukur	Boro	Fallow	T. Aman	16000	43.0%
Rangpur	Mithapukur	Wheat	T. Aus	T. Aman	3800	10.0%
Rangpur	Mithapukur	Wheat	Jute	T. Aman	2000	5.0%
Rangpur	Mithapukur	Potato	Boro	T. Aman	2000	5.0%
Rangpur	Mithapukur	Wheat	Fallow	T. Aman	1000	2.0%
Rangpur	Mithapukur	Potato	Jute	T. Aman	1500	4.0%
Dinajpur	Sadar	Boro	Fallow	T. Aman	7500	26.0%
Dinajpur	Sadar	Wheat	Fallow	T. Aman	5371	19.0%
Dinajpur	Sadar	Wheat	T. Aus	T. Aman	1500	5.0%
Dinajpur	Sadar	Fallow	Fallow	T. Aman	6887	24.0%
Dinajpur	Sadar	Potato	T. Aus/Jute	T. Aman	2200	8.0%
Dinajpur	Sadar	Vegetable	Fallow	T. Aman	2000	7.0%
Dinajpur	Sadar	Fallow	Jute	T. Aman	827	3.0%
Dinajpur	Sadar	Tomato	Fallow	T. Aman	710	2.5%

Table 13—Important Crop Sequences in the Northwest Region (Continued)

Place		Season			Land Area	% of Total Land
District	Thana	Rabi	Kharif I	Kharif II		
Dinajpur	Birol	Wheat	Fallow	T. Aman	9125	29.0%
Dinajpur	Birol	Wheat	T. Aus	T. Aman	3572	11.0%
Dinajpur	Birol	Vegetable	Vegetable	T. Aman	700	2.0%
Dinajpur	Chrirbander	Boro	Fallow	T. Aman	7500	28.0%
Dinajpur	Chrirbander	Wheat	Fallow	T. Aman	5200	19.0%
Dinajpur	Chrirbander	Potato	Jute	T. Aman	1500	5.5%
Dinajpur	Chrirbander	Fallow	T. Aus	T. Aman	2000	7.5%
Dinajpur	Chrirbander	Fallow	Fallow	T. Aman	5000	18.7%
Dinajpur	Chrirbander	Wheat	Jute	T. Aman	950	3.5%
Dinajpur	Chrirbander	Onion	T. Aus	T. Aman	750	2.8%
Dinajpur	Chrirbander	Mustard	Vegetable	T. Aman	1000	3.5%
Dinajpur	Chrirbander	Vegetable	Fallow	T. Aman	500	2.0%
Gaibandha	Polashbari	Boro	Fallow	T. Aman	5125	53.0%
Gaibandha	Polashbari	Wheat	Jute	T. Aman	786	5.0%
Gaibandha	Polashbari	Wheat	Fallow	T. Aman	1258	8.0%
Gaibandha	Polashbari	Potato	Vegetable	Fallow	786	5.0%
Gaibandha	Polashbari	Potato	Boro	T. Aman	629	4.0%
Gaibandha	Polashbari	Mustard	Boro	T. Aman	314	2.0%
Gaibandha	Polashbari	Maize	Fallow	T. Aman	314	2.0%
Gaibandha	Polashbari	Sugarcane	+ Vegetable	Continue	560	3.0%
Gaibandha	Polashbari	Banana	+ Vegetable	-	300	2.0%
Gaibandha	Gobindhaganj	Boro	Fallow	T. Aman	12500	35.0%
Gaibandha	Gobindhaganj	Potato	Boro	T. Aman	5000	14.0%
Gaibandha	Gobindhaganj	Mustard	Boro	T. Aman	2500	7.0%
Gaibandha	Gobindhaganj	Wheat	T. Aus/Jute	T. Aman	2700	8.0%
Gaibandha	Gobindhaganj	Sugarcane	+ Vegetable	Continue	2100	6.0%
Gaibandha	Gobindhaganj	Vegetable	Fallow	T. Aman	2000	6.0%
Gaibandha	Gobindhaganj	Sugarcane	-	-	3239	3.0%

Source: Razzaque (1998).
Note: Only those crop-sequences with at least 2% of total land of the thana under cultivation are included.

and triple cropped land 24%, while the corresponding national figures were 38%, 50% and 12% in 1996-97. Again, there are considerable variations across the 10 thanas in this respect.

A summary of important crop sequences observed in the 10 selected thanas, their incidences and the resulting net financial as well as economic returns on a per hectare basis are presented in Table 14. It is readily observed that although crop-sequence varies widely in the region, the most prevalent one is Boro-Fallow-T. Aman. Not only do 9 out of 10 of the selected thanas adopt this crop-sequence, the percentage of total land devoted to the pattern is also quite high (50.2%), much higher, in fact, than any other crop-sequence observed in the region. Most of the cropping patterns/crop-sequence include T. Aman and this remains the single-most important crop in the region, with about 80% of total cultivable area. Irrigated boro area is also high, claiming about 50% of the arable land. Wheat fits well in a number of cropping patterns (Wheat-T. Aus-T. Aman, Wheat-Fallow-T.Aman and Wheat-Jute-T. Aman) and seem to be widely practiced in the region, although the percentage of land cultivated is still much lower (ranging from 5.0% to 13.2%) as compared to that involving irrigated boro, as we observed earlier. However, wheat is increasingly becoming a major cereal crop in the northwest region because of climatic advantage and is the most important cereal crop next to rice. Net financial return also compares quite favorably with the Boro-Fallow-T. Aman sequence when its production in the rabi season is combined with T. Aus and T. Aman in Kharif I and Kharif II seasons, respectively.

Jute fits well in the cropping patterns based on crops like wheat, potato and other winter crops that compete with boro. However, the land devoted to the production of this crop, combined with either Wheat–T. Aman or Potato-T. Aman, is rather small (around

Table 14—Selected Crop Sequences, Their Incidences and Net Financial and Economic Returns in the Northwest Region

Crop Sequence			No. of Thana(s) adopting the crop sequence	Percentage of total land devoted to the crop sequence (average of respective thanas)	Net Financial Return (Tk./hectare)	Net Economic Return (Tk./hectare)	
Rabi	Kharif I	Kharif II				Import Parity	Export Parity
Boro	Fallow	T. Aman	9	50.2	17081	37854	16344
Wheat	T. Aus	T. Aman	5	8.9	18095	40066	20864
Wheat	Fallow	T. Aman	6	13.2	12601	26184	15556
Potato	Boro	T. Aman	6	7.9	69717	232669	45474
Potato	Jute	T. Aman	4	5.9	64196	224162	44631
Wheat	Jute	T. Aman	4	5.4	14379	35813	21967
Fallow	Fallow	T. Aman	2	21.8	9782	19682	9090
Potato	T. Aus	T. Aman	2	7.5	67912	228415	43528
Vegetable	Fallow	T. Aman	3	5.0	51274	356722	346130
Tobacco	T. Aus	T. Aman	1	26.0	26667	126025	106823
Tobacco	Fallow	T. Aman	1	24.0	21173	112107	101515
Vegetable	Spices	Fallow	1	13.0	57921	343589	343589
Boro	Fallow	Fallow	2	4.0	7299	18172	7254
Fallow	T. Aus	T. Aman	1	7.5	15276	33600	14398
Potato	Vegetable	Fallow	1	5.0	94128	531855	366170
Mustard	Boro	T. Aman	3	4.0	21316	41430	19920
Boro	Boro	T. Aman	1	59.0	-	-	-
Sugarcane	+ Vegetable	Continue	2	4.5	85573	370363	370363

Source: Based on information in Table 13 and authors' calculations.

Note: Only these crop-sequences are included in this table, which have either been adopted in more than one thana or claim at least 5% of total land of the thana.

6%), despite much higher returns when combined with potato. Area under jute is declining due to increasingly lesser demand both in the domestic market and abroad. Potato, on the other hand, is one of the most important cash-cum-vegetable crops in the region, and its acreage, as well as production, has been growing steadily over the last decade. Agro-climatic conditions of the region are ideal for growing potatoes and the crop fits very well in the existing cropping pattern either by itself or as an intercrop. However, there are a number of constraints that impede the large-scale expansion of potato cultivation in the region. Storage, preservation and marketing are major problems from the farmer's point of view. Farmers have to sell immediately following harvest at the lowest price. High storage cost and the fact that the cold storages are generally used for storing seed potatoes are among other major problems (Razzaque, 1998). We shall return to this issue when we discuss the incidence of other high-value crops (or the lack of them) in the cropping pattern in the region. Tobacco-based cropping patterns (combined with either T.Aus - T. Aman or with only T. Aman) claim a reasonably large share of total cultivated land (about 25%), but this is observed to be practised in only 1 (Gangachara thana in Rangpur district) out of 10 of the selected thanas. However, both financial and economic returns of the relevant crop-sequence, especially the latter, remain quite attractive due to the high export demand for this crop.

Vegetables combine either with cultivation of spices or with potato, with land remaining fallow in the Kharif II season. The amount of land devoted to such cropping patterns, however, is small despite high financial and economic returns. That this is so has been alluded to earlier while discussing the crop sequence associated with potato, another high-value non-cereal crop. One can attribute this to a combination of technical and economic factors. 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 non-rice crops to be planted in the same service units. Growing non-rice 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. This may hardly be a preferable option for a risk-averse farmer in Bangladesh. 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 centres) that non-cereal crops are found to be grown under modern irrigation on any significant scale (Mahmud et. al., 1994).

The foregoing analysis brings out the nature of complementarity in the choice of crops in light of observed crop-sequences in different seasons in the northwest region. Since the high and medium-high lands are dominant land types in the region, these conclusions are expected to remain valid for similar land types prevalent in other regions as well. However, it may be worthwhile to repeat this exercise on the basis of observed crop sequences in selected thanas in other regions (with different physical characteristics such as soil types and/or distribution of rainfall). Such an exercise will assume greater significance in highlighting the comparative advantage of different crop-sequences in those areas characterized by medium-low and low lands, which are dominant in the epressed/"haor" areas in the Northeast Region and also the coastal areas in Bangladesh.[37]

[37] For an analysis of the changes in agriculture and economy in flood-prone environment in Bangladesh, see Hossain et al. (2001).

6. POLICY IMPLICATIONS

This paper has analyzed comparative/competitive advantages in the production of various crops and also for different crop sequences/cropping patterns in Bangladesh. The profitability estimates suggest that except for a few import-competing crops such as sugarcane, oilseeds and chillies, the country has a comparative advantage in the production of most crops either for import substitution or for export. Moreover, there are a number of crops, namely vegetables, potato, cotton and onion, whose net financial and economic returns are either as high as or higher than that of HYV rice. The fact that they have performed so poorly despite higher returns is generally attributed to two factors (Mahmud et al., 1994, Shahabuddin, 1999).

First, there are very high risks associated with the marketing of such crops. Development of agroprocessing industries and marketing networks provides effective means for reducing variability in prices. Development of rural infrastructure including roads and inland water transport, rural electrification and communication facilities is an essential prerequisite for integrating localized rural markets with each other and with urban markets. Also, technological improvements can substantially increase profitability so as to compensate for the high price risk associated with such crops. There is considerable scope for increasing the yields of non-cereal crops through better farming practices and varietal improvement even under non-irrigated or semi-irrigated conditions. The real prospects for diversification, however, would still depend on how far technological innovations could make non-cereal 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. The technical and socioeconomic constraints to the diffusion of improved techniques in the case of non-cereal crops are still little understood. Much will depend on how far adaptive research and extension activities can be strengthened to identify and overcome such constraints (Mahmud et al., 1994). In fact, dissemination of improved techniques and better farming practices would require reorientation and improvement of the current research and extension systems which have been largely ineffective in promoting non-rice crops in the past. It may be noted here that by making non-cereal crops competitive through the adoption of modern technology, 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, specially dry season irrigated land, according to agroclimatic suitability.[38]

Secondly, the existing non-farm water management systems do not allow rice and non-rice crops to be planted in the same service units. This discourages the use of modern irrigation for growing high-value but risky non-rice crops since it may often require farmers to allocate all of their land (or most of it) to such crops. It is, therefore, necessary to devise and introduce water management systems that would allow rice and non-rice crops to be grown within the same service units. Also, there are certain constraints to be overcome in promoting the production of non-cereal crops within rice-based cropping system/patterns. Supplementary irrigation during the wet season may be necessary not only for promoting the adopting of summer HYVs but also for ensuring a timely aman crop that would leave room for growing dry-season non-cereal crops. Selective mechanization of agricultural operations may also be needed to overcome the

[38] For example, HYV boro yields are found to be significantly lower on permeable soil types, which are also particularly suitable for growing most non-rice crops (Zohir, 1993).

shortage of human and bullock labor during the peak period immediately following the aman harvests. The recent proliferation of power tillers in the country should contribute significantly towards achieving this goal.[39] Another important policy concern in the context of promoting high-value crops and/or crop diversification is the potential scope for promoting such "intermediate" irrigation technology as that represented by hand-tubewells and pumps. These labor-intensive irrigation techniques are found to be particularly advantageous for small farmers and for growing crops like potatoes, vegetables and spices. Flood control measures can also promote crop diversification by increasing the availability of "higher" land types. But 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 (FPCO, 1991).[40]

Finally, it may be emphasized that diversification into non-rice crops would require intensification of rice production to meet its growing demand due to growth in population and also at the same time, freeing up land for other crops. However, this would call for significant enhancement in agricultural productivity through improved research and extension services, especially in the face of the decline in the availability of cultivable land in the country.

7. CONCLUSIONS

The analysis of comparative advantage carried out in this exercise suggests that the menu of crops that Bangladesh can produce efficiently either for import substitution or for export is quite large. In fact, the profitability estimates and estimated domestic cost ratios indicate that except for a few import-competing crops such as sugarcane,

[39] For an elaborate discussion on this, see Ahmed (2000).

[40] If so, then this would involve a transition from lower non-irrigated land types to higher irrigation ones which may in fact result in more concentration on cereal production (Mahmud et al., 1994).

oilseeds and chillies, Bangladesh has a comparative advantage in the production of most agricultural crops. The economic profitability analysis also demonstrates that Bangladesh has a comparative advantage in the domestic production of rice for import substitution, but not for export. In fact, moving to an export price regime implies a substantial decline in economic profitability for all rice crops. Moreover, when compared with the economic profitability of many non-rice crops, it would appear that the country has more profitable options other than production for rice export.

There are a number of crops, namely vegetables, potato and onion whose financial and economic returns are either as high as or higher that that of HYV rice. The fact that they have performed so poorly despite their higher returns can largely be attributed to high price risks associated with the marketing of such crops. The development of agroprocessing industries and marketing networks can provide effective means for reducing variability in prices and the development of rural infrastructure, including roads and inland water transport, rural electrification and communication facilities, is an essential prerequisite for integrating localized rural markets with each other and with urban markets. At the same time, market links need to be established abroad and appropriate grading and processing facilities developed to promote exports of these products. The economic profitability of vegetable production for export has been observed to be fabulously high as compared with most other crops. However, their exports are constrained by a lack of experience with these crops in Bangladesh, as well as a variety of marketing problems including product quality, acceptable packaging, high transport costs and market access. These problems need to be addressed to exploit the potential of crop diversification in the country. The real prospects for crop diversification, however, would still depend on how far technological innovation could make non-cereal crops competitive under conditions of modern irrigation.

APPENDIX

Table A.1—Crops Yields, Cost of Irrigation, Rental Value of Land and Use of Labor and Chemical Fertilizers in Crop Production Activities

Crop*	Irrigation Technique	Yield** (kg/hectare)	Rental Value of Land (Tk/hectare, in 1990-91 prices)	Cost of Irrigation (Tk/hectare, in 1990-91 prices)	Labor (person days/ hectare)	Fertilizer*** (kg/hectare)
Boro						
HYV	Modern	4344	8366	3678	198	357
Local	All	2189	7840	397	135	69
Aman						
HYV	Modern	3588	6833	268	215	259
HYV	Rainfed	3531	6833	0	184	261
HYV	All	3499	6833	268	189	259
Pajam	All	2956	7266	258	194	173
Local T	Rainfed	2096	6661	28	160	79
Local B	Rainfed	1646	2817	48	132	26
Aus						
HYV	Rainfed	2998	8047	0	164	226
HYV	Modern	3627	8047	576	202	242
HYV	All	3090	8047	576	178	242
Local B	Rainfed	1554	3999	9	161	85
Wheat	Modern	2292	4731	1437	159	313
Wheat	Non-irrigated	1959	4731	0	146	193
Wheat	All	2199	4731	843	156	272
Jute (White)	Rainfed	1530	4988	0	247	112
Jute (Tossa)	All	1765	4782	298	245	135
Cotton	Rainfed	1306	4134	97	211	235
Tobacco	Modern	1577	7113	1346	236	347
Tobacco	All	1445	7113	1346	255	347
Sugarcane	Modern	71333	12013	427	318	541
Sugarcane	Non-irrigated	54550	12013	0	341	511
Oilseeds						
Mustard	Traditional/ Non-irrigated	894	6125	136	118	207
Sesame	Traditional/ Non-irrigated	775	5946	0	196	92
Linseed	Traditional/ Non-irrigated	508	2077	0	51	32

Table A.1—Crops Yields, Cost of Irrigation, Rental Value of Land and Use of Labor and Chemical Fertilizers in Crop Production Activities (Continued)

Crop*	Irrigation Technique	Yield** (kg/hectare)	Rental Value of Land (Tk/hectare, in 1990-91 prices)	Cost of Irrigation (Tk/hectare, in 1990-91 prices)	Labor (person days/ hectare)	Fertilizer*** (kg/hectare)
Pulses						
Masur (Lentil)	Traditional/ Non-irrigated	818	3127	44	82	92
Gram	Traditional/Non-irrigated	767	2068	0	81	81
Khesari	Traditional/ Non-irrigated	1088	3314	0	73	73
Spices						
Chilly (Dry)	Modern	897	7320	1220	264	435
Chilly (Dry)	Traditional/ Non-irrigated	699	7320	0	407	221
Onion	All	8078	5182	452	321	192
Potatoes						
HYV Potato	Modern	19417	6208	1582	299	819
HYV Potato	Traditional/Rainfed	18372	6208	0	314	695
HYV Potato	All	18502	6208	1582	295	695
Local Potato	All	7961	6790	926	237	327
Vegetables						
Brinjal	Traditional	12273	8105	0	391	464
Brinjal	Modern	16484	8105	1132	514	824
Radish	Modern/Traditional	10722	8267	328	267	433
Cucumber	Modern/Traditional	8449	10230	988	164	317
Tomato	Modern/Traditional	16365	7628	575	332	372
Cabbage	Modern/Traditional	19909	8203	1689	275	502
Barbati (Long yard Bean)	Traditional/Non-irrigated	7696	6490	0	352	304
Arum	Traditional/Non-irrigated	13912	8072	0	296	653

Source: These estimates are based on the findings of farm survey in Zohir (1993) and Mahmud et al, (1994).

Note: * HYV = High-Yielding Variety, T = Transplanted, B = Broadcast.
** Does not include by-products.
*** Chemical fertilizers other than Urea, TSP & MP are not included here.

Table A.2—Harvest (Farmgate) Prices of Rice and Non-Rice Crops, Prices of Chemical Fertilizers and Agricultural Wage Rates in Bangladesh (1996/97 to 1998/99)

Crop	1996/97	1997/98	1998/99	Average
Boro paddy (Tk/kg)				
Local	5.65	6.39	6.37	6.14
HYV	5.51	6.40	6.48	6.13
Aman paddy (Tk/kg)				
Local	5.54	7.04	8.72	7.10
HYV	5.58	7.12	8.90	7.20
Pajam	6.19	7.78	9.67	7.88
Aus paddy (Tk/kg)				
Local	5.02	4.99	6.90	5.64
HYV	5.07	4.97	7.33	5.79
Wheat	7.34	8.05	8.50	7.96
Jute	9.94	5.42	9.72	8.36
Cotton	20.81	29.33	30.03	26.72
Tobacco	23.44	26.76	25.96	25.39
Sugarcane	1.10	1.10	0.99	1.06
Mustard	16.34	15.49	16.39	16.07
Sesame	15.16	15.62	17.04	15.94
Linseed	15.65	15.68	15.40	15.58
Masur (Lentil)	20.40	18.49	20.14	19.68
Gram	17.01	18.54	21.27	18.94
Khesari	9.85	9.38	9.24	9.49
Chilly (Dry)	44.58	30.76	61.44	45.59
Onion	7.55	14.35	22.70	14.87
Potato (Fresh)	5.21	5.01	5.68	5.30
Brinjal	5.13	5.80	6.56	5.83
Radish	2.39	2.96	3.75	3.03
Cucumber	3.76	5.65	6.40	5.27
Arum	4.03	4.65	5.10	4.59
Barbati	7.14	7.12	7.52	7.26
Tomato	5.68	6.95	9.50	7.38
Cabbage	3.16	4.05	3.60	3.60
Chemical Fertilizer (Tk/kg)				
Urea	4.91	5.98	6.02	5.64
TSP	12.37	14.02	13.91	13.43
MP	7.21	8.32	9.23	8.25
Human Labor (Tk/day)				
Wage rate (without food):	49.28	52.15	56.06	52.50

Sources: 1. Directorate of Agricultural Marketing.
2. Bangladesh Bureau of Statistics.

Table A.3—Specific Conversion Factors of Various Agricultural Products

Crop	Price Parity Basis	Specific Conversion Factor
Paddy	Import	1.29
	Export	0.88
	Non-traded	1.06**
Wheat	Import	1.07
Jute	Export	1.35*
Cotton	Import	0.88
Tobacco	Export	2.93**
Sugarcane (Sugar)	Import	0.65
Sugarcane (Gur)	Import	0.38**
Oilseeds (Oil)	Import	0.41**
Oilseeds (Seed)	Import	0.85**
Pulses	Import	1.31 (H)**
		1.05 (L)**
Chilli (Dry)	Import	0.67**
Onion	Import	0.88**
Potato (Fresh)	Import	2.32**
	Export	0.71**
	Non-traded	1.27**
Brinjal	Export	3.73**
	Non-traded	1.26*
Radish	Export	9.99**
Cucumber	Export	4.73**
Barbati	Export	4.15**
Arum	Export	5.53**
Tomato	Export	4.78**
Cabbage	Export	7.29**

Notes: (1) * represents the specific conversion factors estimated by Shahabuddin and Syed (1998) earlier.
(2) ** represents the specific conversion factors estimated by Mahmud et al. (1994) earlier.
(3) Oilseeds include mustard, sesame and linseed.
(4) Pulses include masur (lentil), gram and khesari.

Table A.4—Specific Conversion Factors of Agricultural Inputs

Inputs	Price Parity Basis	Specific Conversion Factors
Chemical Fertilizers		
Urea	Export	0.75
TSP	Import	0.77
MP	Import	0.98
Human Labor	-	0.85*
Draft Power	-	0.914 (SCF)
Seeds	-	Same as crops
Pesticides	-	0.914(SCF)
Irrigation	-	0.79*
Manure	-	0.914 (SCF)

Note: (1) * represents the specific conversion factors estimated by Shahabuddin and Syed (1998) earlier for 1995 reference year.
(2) SCF represents the standard conversion factor estimated by the Resident World Bank Mission in Dhaka (1998).

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