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Rice Technologies: Strategic Choices and Policy Options[1]

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This Policy Brief discusses the issues of maintaining national food self-sufficiency in Bangladesh in the face of emerging challenges in the agriculture sector. It has been funded by the UK Department for International Development (DFID).

1. Introduction

In Bangladesh, as in most developing countries, there is a tension between the need to maintain the food price at a level which (a) provides an incentive for farmers to adopt new technologies and grow more food, while (b) ensuring that the poor can afford to buy food and that wages, elsewhere in the economy (e.g., the garments industry), can be kept low to promote exports.

A key way to tackle this problem is to develop new agricultural technologies, which make it possible to produce food more cheaply (by lowering the unit costs of production) and do so in environmentally sustainable ways. Producing grain domestically saves the country $20 billion of foreign exchange earnings annually, which is the cost of food the country would have to import if it did not produce it - a key consideration at times of economic downturn. In addition, the agriculture sector is a huge employer of labour - about 60 per cent of the population works in the sector, which buffers the country when other sources of employment are strained.

Since the early 1990s, the Bangladesh economy has grown at over 5 per cent annually. GDP/capita increased from $211/capita in 1973 to $554/capita in 2007/08 and poverty declined from 75 per cent in the mid-1970s to 40 per cent in 2005. Bangladesh has an increasing, largely urban, middle class with rapidly rising income, while poor and ultra-poor people still live mainly in rural areas.

Since Independence in 1971, Bangladesh has tripled food grain production (from approximately 10 million tonnes in 1970/72 to almost 30 million tonnes in 2007/08). This "Green Revolution" has enabled Bangladesh to increase food availability to meet the demands of a rapidly growing population. Bangladesh still imports wheat and some rice especially at times of disaster (e.g., floods, cyclones), but the country is largely self-sufficient in rice in normal years.

The "Green Revolution" took place mainly in rice and involved a transition from a cropping system based on local varieties grown mainly in the monsoon season (the aman crop) to cultivation of irrigated high-yielding varieties of rice during the dry season (the boro crop). See Figure1.

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Figure 1 : The Green Revolution in Bangladesh

Early-1970s *		Mid-2000s
Total foodgrain production 10 m tonnes		Total foodgrain production 28-30m tonnes
Average rice yield 1.0 t/ha		Average rice yield 2.6 t/ha
Under 7 per cent of net cultivated area irrigated		Over 70 per cent of net cultivated area irrigated
Fertiliser use 45 kg/ha (net sown area basis)		Fertiliser use 400 kg/ha (net sown area basis)
Rainfed Aus and Aman 78 per cent of output		Irrigated boro 55 per cent of output
Population of Bangladesh 71million		Population of Bangladesh 145 million
Foodgrain availability/capita 410gm/day		Foodgrain availability/capita 476 to 500 gm/day

*** 1972/73**

This rapid increase in rice production was made possible by:

High-yielding varieties (HYVs): Breeding HYVs suited to Bangladesh conditions. The first generation of these, which became available in the 1970s and 1980s (e.g., IR-8, BR1, BR3, IR20, BR11), used Philippines genetic material and yielded 5.0-6.5 t/ha. The second generation varieties introduced since the mid-1990s (e.g., BRRI Dhan 28 and BRRI Dhan 29) yield up to 6.5 t/ha and are based on elite lines developed at BRRI and other international material (e.g., from Sri Lanka). These varieties now cover 60 per cent of the boro area. In the last few years, hybrids (e.g., Heera, Aloran) yielding up to 7.5 t/ha have been introduced and now cover almost 15 percent of the boro area (see Table 1). Irrigated boro rice yields are comparable to irrigated rice yields elsewhere in the region (e.g., Punjab, China, Indonesia).

Minor irrigation: The rapid spread of individually owned, mainly diesel operated, shallow tubewells (STW) contributed to the fast expansion of boro rice. Over 70 per cent of the net cropped area is now irrigated. STWs cover 65 per cent of the total irrigated area and 80 percent of total area irrigated by groundwater. Deep tubewells and surface irrigation account for the remaining 35 per cent. The growth of local manufacturing of irrigation equipment spare parts and repair facilities generate employment and improve irrigation services.

Fertiliser and pesticides: The rapid uptake by farmers of the fertiliser (urea, Triple Super Phosphate (TSP) and Muriate of Potash (MP)) needed to cultivate HYVs. Fertiliser use in Bangladesh is currently about 400 kg/ha (net sown area basis), which is comparable to neighbouring countries. Pesticides used to be needed, but new HYVs display host plant resistance (pesticides

Table 1: Comparison of popular rice cultivars in Bangladesh

	BR11 (Mukta)	BRRI Dhan 28	BRRI Dhan 29	Hybrids
Year of release	1980	1994	1994	Various
Growing season	Aman	Boro	Boro	Boro
Plant height (cm)	115	90	95	approx 1m
Growth duration (days)	145	140	165	115 to 135
Average yield (t/ha)	6.5	5.5	7.5	7.0-8.5

Source: BRRI, 2007. Adhunik Dhaner Chas: 13th edition. Gazipur: Bangladesh Rice Research Institute.

are only required now for Stem Borer). However, herbicides are becoming increasingly important for weeding because of escalating wage rates and it is important that products are used that do not cause environmental damage.

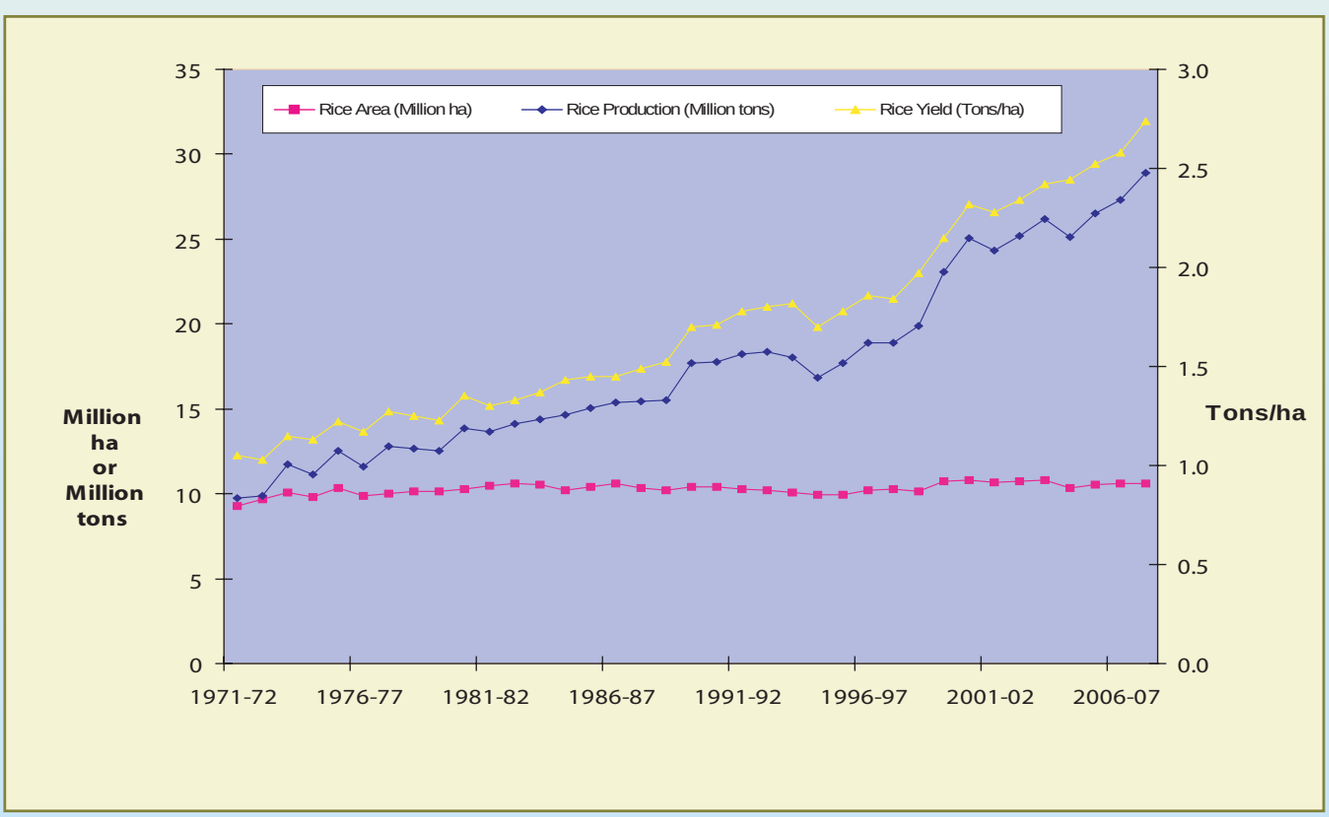
Since there was relatively little uncultivated land in Bangladesh by the 1970s, most of the production increase has come from higher yields and from cultivating land more intensively (the cropping intensity[2] increased from 145 per cent in the 1970s to 175 per cent in the 2000s). Although HYV boro mainly displaced other rice crops, some pulses (e.g., lentils, chickpea, keshari), which were important sources of protein for the poor, were also displaced.

The new rice technologies are scale-neutral (i.e. small and marginal farmers can cultivate and benefit from the new varieties as well as larger farmers) and have been adopted widely by all classes of farmer. This is a key consideration in Bangladesh where almost 90 per cent of farmers cultivate less than one hectare of land.

Improved varieties of wheat have been promoted in Bangladesh since the 1970s but production has never exceeded two million tonnes. Wheat has been grown mainly on lighter soils in north-west Bangladesh, where there is a longer winter season. In recent years, wheat is being displaced from these lands by maize, which yields higher and is used for poultry feed.

Figure 2 shows how rice production and yield has increased over the last 30 years, while the area has increased only slightly. Figure 3 indicates how rapidly the use of urea (nitrogen) fertiliser has grown, relative to Muriate of Potash (MoP) and Triple Super Phosphate (TSP). Figure 4 shows how the irrigated area has almost tripled in Bangladesh in the last 25 years.

Figure 2: Trends in area, production and yield of rice in Bangladesh: 1971/72 - 2007/08



[2] The 'cropping intensity' indicates the average number of crops grown in an area. A cropping intensity of 100% indicates that a single crop is grown; 200% indicates double-cropping.

Figure 3: Trends in per hectare use of different fertilisers in Bangladesh: 1980/81-2006/07

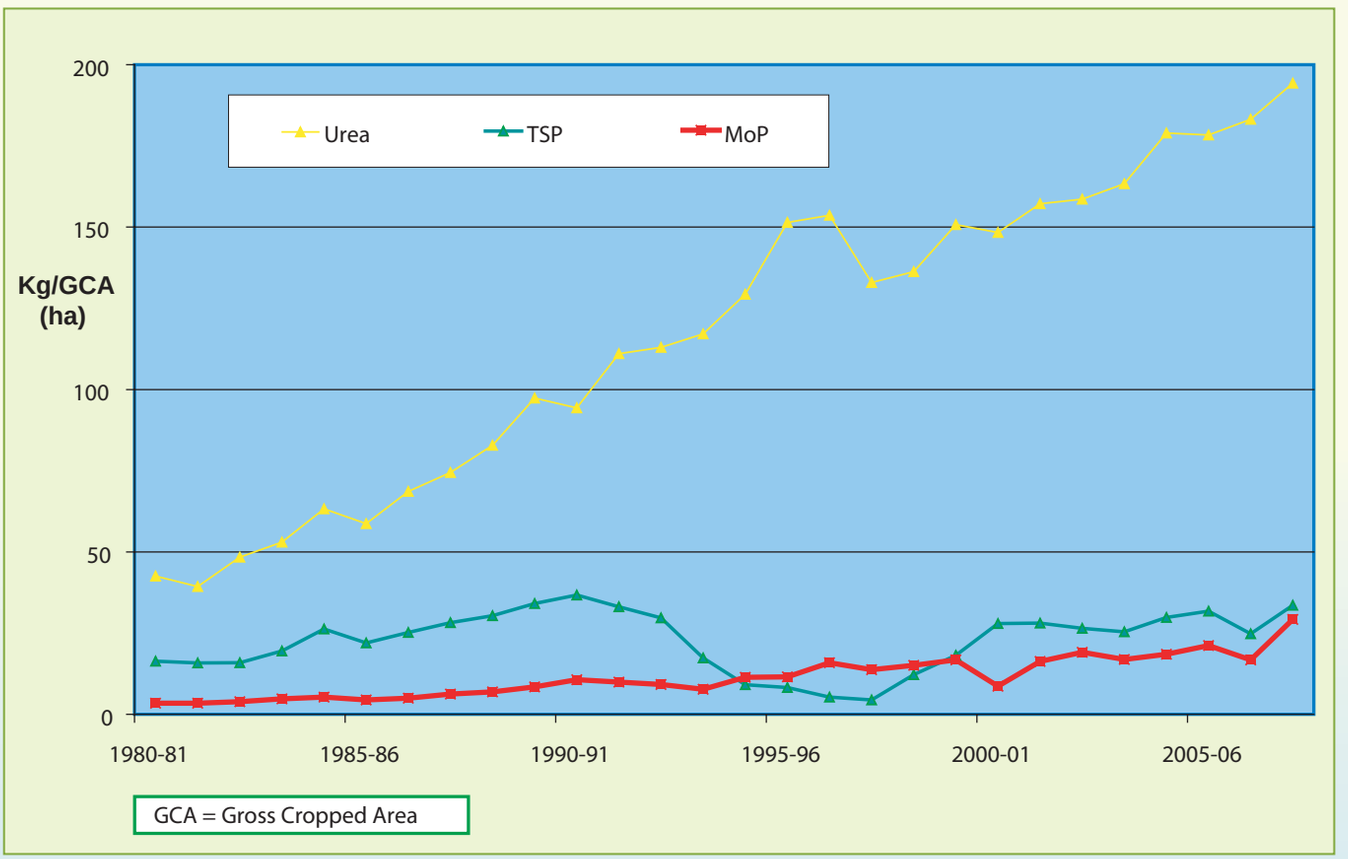
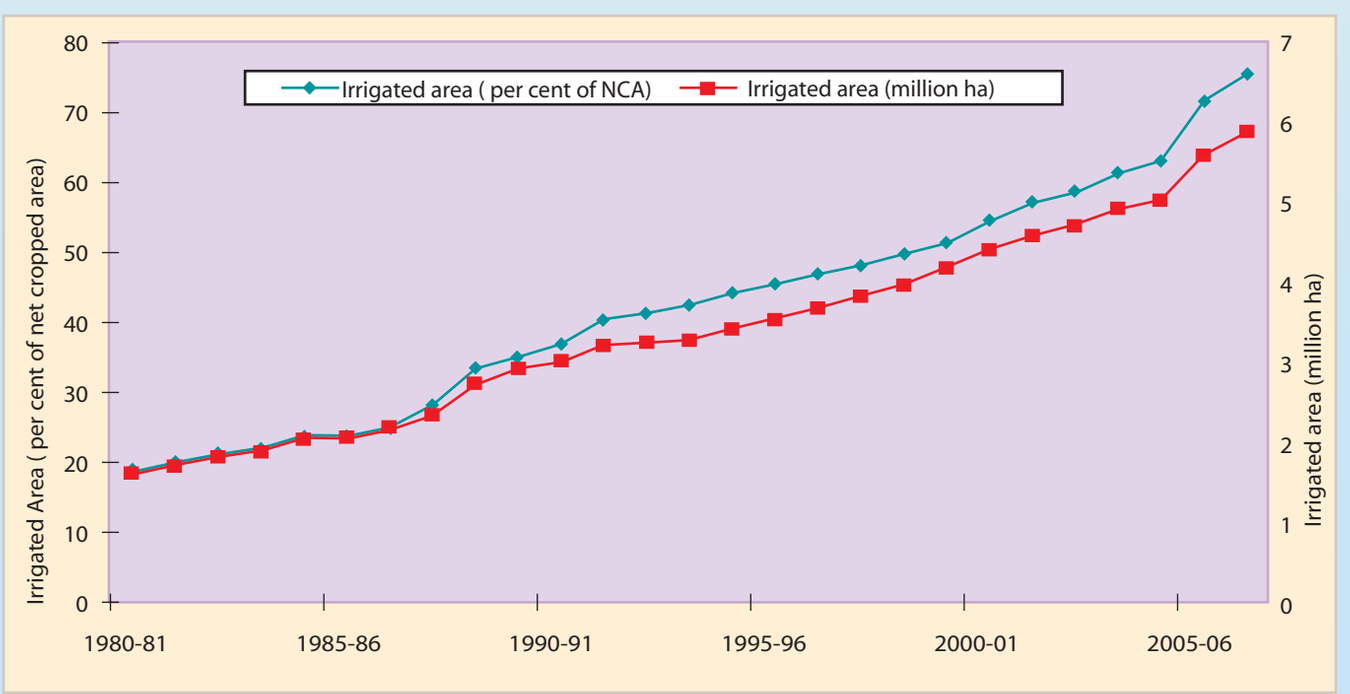


Figure 4: Trends in irrigated area in Bangladesh 1980/81-2006/07



2. Future Challenges

Technologies for Unfavourable Areas

Although the new technologies have proved effective in "high potential" areas, they are not suited to more challenging agro-ecologies. These include areas with low and/or erratic rainfall (e.g., parts of west and north-west); hilly regions; sandy river chars; deeply flooded areas, where there is risk of submergence; and coastal areas with high salinity. These agro-ecologies cover roughly one-third of Bangladesh.

"Challenging" agro-ecologies cover a third of the country but generating technologies for these environments was not a high priority of the Bangladesh Rice Research Institute (BRRI) until the 1990s. In the 1970s and 1980s, BRRI followed the International Rice Research Institute's research strategy, which focused on high potential areas (because unfavourable environments in Asia account for less than one-tenth of the rice area). BRRI only started work on the unfavourable environments, when IRRI changed its approach.

Non-Rice Agriculture

Slower progress has been made, over the last 30 years, in the spread of improved non-rice crops and non-crop agricultural technologies. Notable exceptions to this are:

- the fisheries sector, where modern technologies have been developed and disseminated for semi-intensive and intensive aquaculture of fish and shrimp/prawn;
- the poultry sector, where there has been a rapid expansion of private sector broiler and layer farms, which has been facilitated by the development of vaccines and diagnostic techniques for key poultry diseases. The recent threat of Avian Influenza warrants promotion of biosecurity measures at the farm level.

There have also been advances in (a) the use of improved varieties of hybrid maize, vegetables and fruits, with seeds imported by the private sector; (b) the potato sector; and (c) cattle rearing and beef fattening and dairy production as livelihood activities by the poor.

Over the next 20 years, the agriculture sector will face the twin challenges of (a) increasing production of food grain to meet the needs of the growing population, (b) diversifying to produce more livestock, fisheries and horticultural (vegetables and fruits) products, to achieve balanced nutrition and to meet the needs of the burgeoning middle class. Bangladesh is likely to become a middle-income country by 2015.

3. What Needs to be Done?

Rice Breeding

The first and second generation HYV varieties are now approaching saturation. There are very few suitable areas where these varieties are not already being grown. Given this, a new strategy is needed. This should involve:

***Hybrids*:** Develop and/or import new hybrid varieties that will increase yields in the high potential areas by 15-20 per cent (over BR29). Although the farmer who grows hybrids has to purchase new seeds every year (at a cost of Tk200/kg compared to TK20-30/kg for HYVs) and the market price of hybrid grain is lower than HYVs (because of its perceived poorer eating quality), it is still considerably more profitable for the farmer. Most hybrid seed is imported from China, but Bangladesh (e.g., BRAC, Supreme Seeds Ltd) is beginning to develop its own hybrids and to produce hybrid seeds. In time, the seed cost is likely to come down[3].

***Focus on the cropping system*:** Develop new HYVs that will make it possible to increase cropping intensity by shortening growing durations so that a maize, potato, pulse or oilseed crop can be grown during the winter season, in the period between the harvest of the aman rice and transplanting the boro rice. This should increase the overall productivity per hectare and raise farmers' profits. BR11 has a field-duration of 145 days, BR29 of 165 days but BR33 (the shortest maturity BR variety) has a much shorter duration of only 118 days. A new BRAC variety, Shakti, while slightly lower yielding, has a field-duration of only 115 days. In Vietnam, the most popular rice varieties now mature within 90 to 100 days.

***Focus on unfavourable environments*:** Develop new varieties for the unfavourable areas, with the active participation of farmers, focusing on:

- saline tolerant varieties, for coastal areas (BR47, the first salt-tolerant variety is under evaluation; more varieties are needed);

[3] A hybrid plant results from the selective cross-breeding of parent plants which pass their best features onto first generation seeds. Hybrid seeds should not be confused with transgenic seeds that have been genetically altered or modified using molecular techniques such as protein engineering.

- submergence tolerance for areas at risk of flash flooding (e.g. the deep flooded and poorly drained areas and the hoars), which can stand being submerged for a week or more (current HYVs die after 2 days). The International Rice Research Institute (IRRI) has incorporated Sub1 gene in Swarna-a widely adaptable variety in South Asia. BRRI is working to achieve this with BR11. Faster development and farmer-participatory evaluation of these varieties is needed;

- shorter duration, possibly deeper-rooting, varieties for areas where rainfall is scanty and unreliable (e.g., more varieties like BR33), as part of a monga mitigation, cropping intensification and diversification, and drought-tolerance strategy and to help generate employment in harvesting the crop for the landless during the monga season.

Developing these varieties will be essential in facing up to the challenge of climate change.

***Focus on tolerance to arsenic uptake*:** Develop new varieties that reduce the uptake of arsenic in areas where arsenic contaminated groundwater and soil is a problem.

***Protect arable land*:** Minimise the loss of arable land due to housing settlement, rural industrialisation and infrastructure construction (currently estimated 1 per cent of arable land annually) through appropriate land use planning.

***Improve soil fertility*:** In the face of declining organic matter content in crop lands, promote steps to enhance soil fertility (e.g., through promoting soil health improvement technologies such as soil testing, compost, green manuring).

Improving Agronomic Practices

Although irrigated boro rice yields are comparable to irrigated rice yields elsewhere in the region, improved agronomic practices could increase these further. Key focus areas include:

- hybrid varieties, which require higher levels of investment than HYVs, thus giving farmers the incentive to invest in improved agronomic practices (e.g., careful seedling, water, nutrient and weed management based on the System of Rice Intensification (SRI));

- difficult environments, where careful agronomic practices are likely to be very important (such as water-saving) in gaining the most from the cultivation of existing and improved varieties;

- adjusting fertiliser subsidies (to keep relative fertiliser prices in favour of phosphate and potash), which currently favour high urea usage and are resulting in unbalanced fertiliser doses, causing depletion of soil fertility in many areas (see Policy Brief No. 0904).

• farm mechanisation: shortage of farm labour generally in peak periods of crop operations has led to increasing demand for locally made machinery (e.g., power tillers, diesel run paddy threshers, urea super granule applicators, and maize shellers). Private manufacturers need financial and technical support to improve design and marketing of new technologies.

Strengthening Research and Extension Systems

The performance of the public research institutes should be strengthened. Leadership and management needs to be made more effective and the capacity of scientists should be enhanced in key new areas (e.g., biotechnology; participatory client-led research), for example through research fellowships (PhD and post-doctoral levels) and links with the international research institutes and other global centres of excellence. This is being addressed, in part, through the World Bank supported National Agricultural Technology Project.

Research institutes also need to develop better links with neighbouring countries, so that they are able to share facilities (e.g., to speed up plant breeding) and do more joint programmes to address shared problems.

The extension system also needs to be transformed so that it is more demand-driven and responsive to farmers' needs. Extension staff need training and re-orientation to become effective promoters of new technology. They need the most recent information on improved technologies and skills to work with farmers to help them solve location-specific problems.

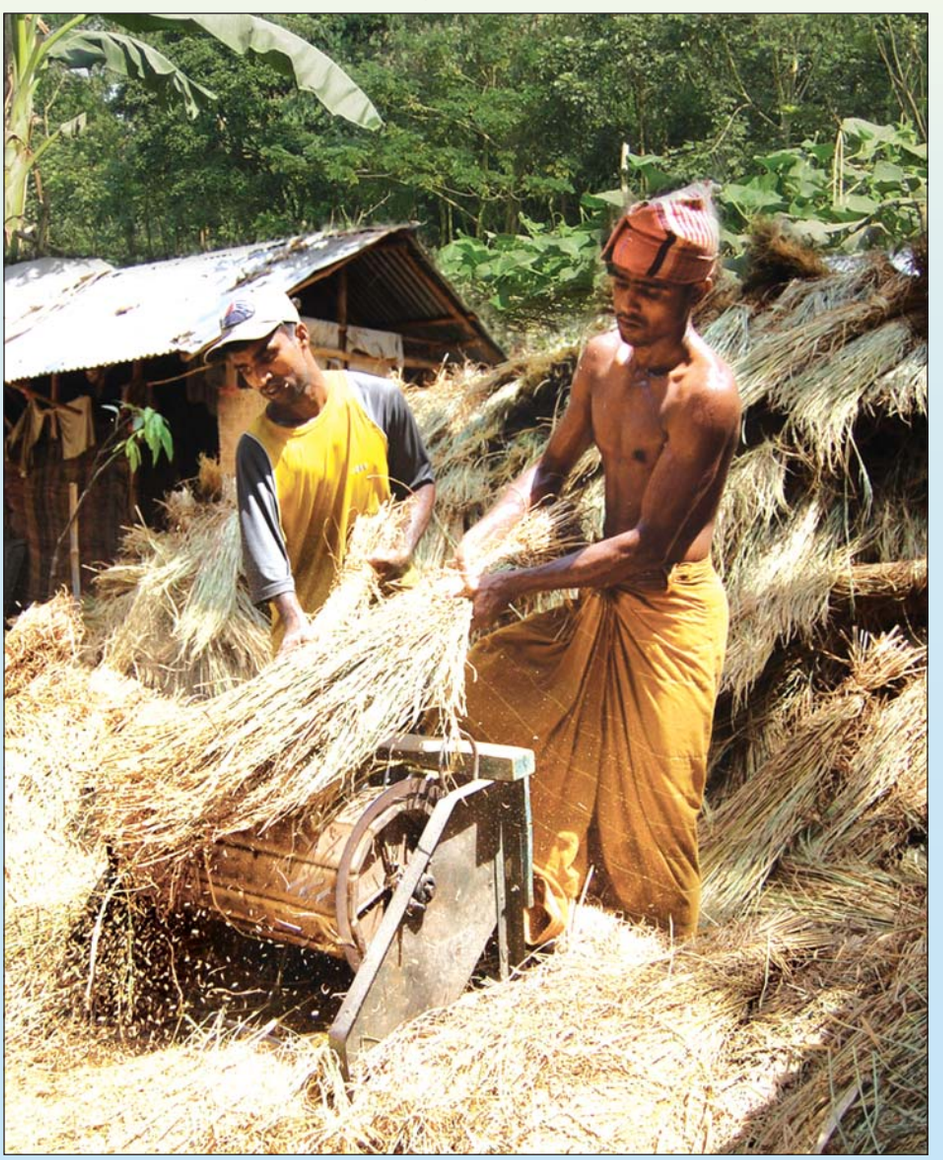
Agricultural Diversification

With rising incomes the demand for animal, fish and horticultural products, and for the production of grains other than rice as animal feed, will grow rapidly. Production of these higher value commodities will need to be promoted through private sector-led value chain development and through public-private partnerships. Continuous technology development that increases rice productivity has an important contribution to make to agricultural diversification by freeing land for other purposes.

4. Conclusion

Although the agriculture sector's share of gross domestic product (GDP) has fallen since the 1970s, agriculture is still critically important to the economy, poverty reduction and food security.

Rice is the main food crop of the country and the performance of the agricultural sector is to a large extent determined by rice. Because of population and income growth, the demand for rice is expected to rise by over 1.5 per cent annually for the next few decades (equivalent to 330,000 tons/year).



This presents a major challenge to policy makers, researchers and extension staff. How can Bangladesh maintain national food self-sufficiency at a time when agricultural diversification is putting increasing pressure on scarce land resources and the land available for rice cultivation is declining by up to one percent a year due to river erosion, urbanisation, housing needs and infrastructure development?

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