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**IFPRI Discussion Paper 01199**

**July 2012**

**Review of Input and Output Policies for  
Cereal Production in Bangladesh**

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## **INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE**

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IFPRI gratefully acknowledges the generous unrestricted funding from Australia, Canada, China, Denmark, Finland, France, Germany, India, Ireland, Italy, Japan, the Netherlands, Norway, the Philippines, South Africa, Sweden, Switzerland, the United Kingdom, the United States, and the World Bank.

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## ABSTRACT

In Bangladesh, supportive government policies have played a crucial role in the rapid growth of the cereals sector, and rice in particular. Despite this growth, the country remains a net importer of rice. Even as Bangladesh struggles to achieve food security, the country's cereal sector faces new challenges. What are these challenges and what should be the country's response? With these questions in mind, this paper reviews the key policies of agricultural inputs and outputs in Bangladesh that are crucial for improving cereal production in the country. On the input side, the review covers seed, fertilizer and agrochemicals, irrigation/water, farm equipment, research, extension, and agricultural credit. The paper also provides an overview of the policies concerning agricultural output markets, with a particular reference to rice, the main staple crop in the country.

The review shows that agriculture, especially rice output, in Bangladesh has grown impressively in the last two decades. A combination of factors seems to have driven these gains: increased access to irrigation; widespread adoption of high-yielding varieties; growth in the use of inputs such as fertilizer, pesticides, and others; and increased efficiency in the output markets. These drivers of agrarian growth received an impetus from the government's shift in policy of moving away from a largely public sector-controlled structure to one in which private-sector participation gained significance in both input and output markets.

The review also shows that despite large gains in efficiency of both input and output markets, several traditional problems continue to plague Bangladesh's agricultural sector. Landholdings are mostly small and often fragmented, which limits the capacity of farmers to access credit, quality inputs, and modern technology. In addition, the input sectors themselves continue to face many of the traditional problems. The seed sector, for example, is dominated by the informal sector, which is outside any legal, regulatory, or quality-monitoring systems. The agricultural research system, dominated by the public sector, continues to face shortages and volatility in its funding, weak management, and ineffective institutional arrangements for undertaking high-quality and relevant research. The public extension system too faces similar funding, manpower, and institutional shortcomings. Ease of access and the coverage of the formal financial sector are still major problems, despite the rapid growth of a diverse set of players in the financial system, such as banks, cooperative societies, and microfinance organizations. Besides these sector-specific problems, overall infrastructure bottlenecks in the country, such as with transportation and electricity sectors, pose problems in accessing inputs and technologies.

Policymakers in Bangladesh are now confronted by numerous new and emerging challenges, which can prove to be a threat to the future of agriculture. Some of these challenges are the result of the negative fallout of current agricultural practices and policies, such as excess groundwater withdrawals for irrigation; decline in soil fertility, some of which is the result of excessive and unbalanced use of fertilizers, pesticides, and other agrochemical inputs; and other problems caused by intensive mono-cropping of rice. Past policies that aimed at promoting growth have not paid much attention to regulating input use patterns, resulting in some of these negative consequences.

Other emerging problems relate to wider changes in the natural environment as well as shifts in world markets and trade, which have consequences for Bangladesh's agricultural sector. In reassessing its agricultural policies, Bangladesh now has to balance the twin challenges of ensuring sufficient growth in output while promoting judicious use of natural resources to maintain good environmental health. At the same time, the country has to evolve strategies for coping with volatility in world markets through regional solutions with neighboring countries.

**Keywords: Bangladesh, agriculture, input policies, output policies**

## **ACKNOWLEDGEMENTS**

This paper was prepared as a part of the Cereal Systems Initiative for South Asia (CSISA) project. The authors gratefully acknowledge the funding received under CSISA for undertaking this work.

## 1. INTRODUCTION

Bangladesh is a highly populated country (150 million in 2011), with a very high population density (1,045 persons per square kilometer in 2011), where the population growth rate is still fairly high (1.4 percent annual average during the 2000s, down from 2.7 percent during the 1980s and 2.1 percent during the 1990s). Agriculture accounted for 47 percent of the total employment in the country in 2010, and not surprisingly, much of the population is still agricultural, though this has declined over time from about 72 percent in 1980 to 45 percent in 2010 (Ministry of Finance 2010). Cereal crops, predominantly rice, are the mainstay of Bangladesh's agriculture. In recent years, with the spread of irrigation and the adoption of high-yielding varieties (HYVs), fertilizer, and other agricultural inputs, rice has become an even more important crop for Bangladesh, as a source of both food and income for farmers. Since the 1980s, Bangladesh has witnessed significant growth in agriculture, particularly with rice, and in more recent years maize. This growth in output has helped Bangladesh achieve a measure of self-reliance to meet foodgrain requirements. Government policy reforms related to various agricultural input sectors, such as the seed, fertilizer, and irrigation sectors, are believed to have played an important role in Bangladesh's agricultural growth.

Bangladesh has witnessed a transition from a public- and parastatal-dominated policy regime to one in which both input and output sectors have been liberalized to a large extent. Starting from the early 1980s, government control and public intervention in input markets as well as in the foodgrain procurement and distribution markets has seen a decline. The results of these policy shifts have had varying degrees of success across different sectors on the input side and on the output side. In some sectors, such as the irrigation sector, the policy of deregulation led to a boom in groundwater irrigation; in other areas, such as the fertilizer sector, deregulation has faced numerous challenges. There is still much scope for progress in input sectors as new threats and challenges emerge from changes in the environment and unsustainable input usage.

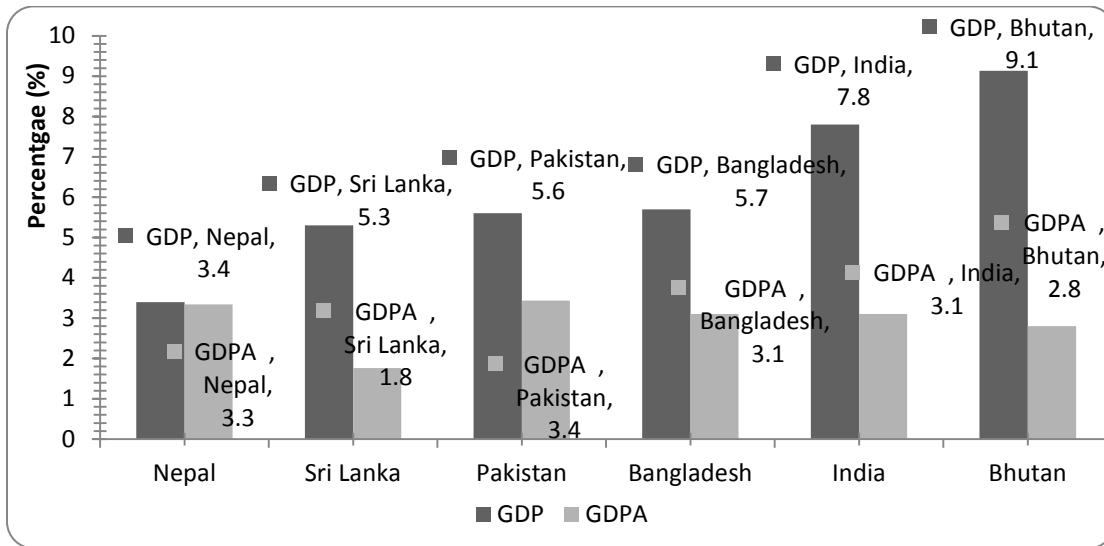
In this context, it is important to examine the existing status, policies, and institutional structures related to the various agricultural input sectors, output marketing, and procurement of foodgrains to examine their impact on the trajectory of growth in the past. This is necessary in order to arrive at an understanding of the challenges and limitations of existing policies that might serve to hinder agricultural growth in Bangladesh. With this objective, this paper examines the key agriculture input sectors—seed, fertilizer, water, agricultural equipment, research and extension, and agricultural credit—drawing upon numerous secondary sources, policy documents, and data from the Ministry of Agriculture publications.

The remainder of the paper is organized as follows. In Section 2, the authors briefly examine the performance trends of key cereals in recent years in Bangladesh. Section 3 covers the status, policies, programs, and challenges relating to each of the agricultural input sectors. Section 4 reviews output marketing policies and institutions in Bangladesh. The final section summarizes the key messages of the paper and explores possible areas and objectives that offer scope for partnership and cooperation among the government, Cereal Systems Initiative for South Asia (CSISA) partners, and other development partners.

## 2. AN OVERVIEW OF AGRICULTURE IN BANGLADESH

In recent years, Bangladesh's agricultural sector has witnessed growth of approximately 3 percent, which equals or surpasses growth in some of its South Asian neighbors (Figure 2.1). Although, on average, the rate of growth of agriculture shows good signs, the year-to-year growth in gross domestic product from agriculture (GDPA) shows a great deal of volatility (Figure 2.2). Also, it can be seen that the overall contribution of the agriculture sector to Bangladesh's economy has been on the decline, as is the case with most developing countries in transition. Nevertheless, the overall GDP growth of Bangladesh's economy does seem to show fluctuations, which are in sync with the swings in GDPA growth (Figure 2.2).

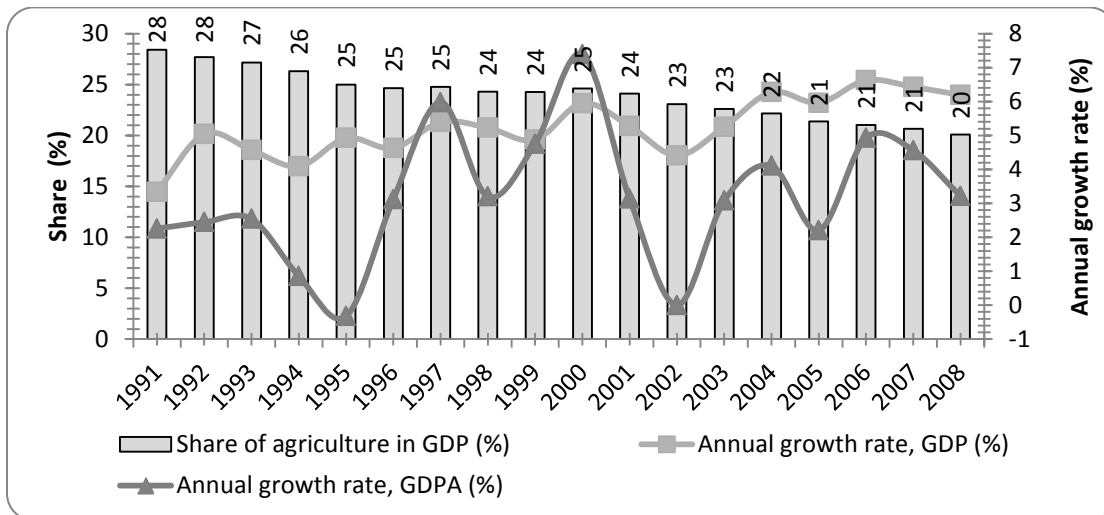
**Figure 2.1—Gross domestic product (GDP) and gross domestic product from agriculture (GDPA) and allied: Average annual growth rates, 2000-07**



Source: World Bank 2009.

Note: Arranged in increasing order of GDP growth.

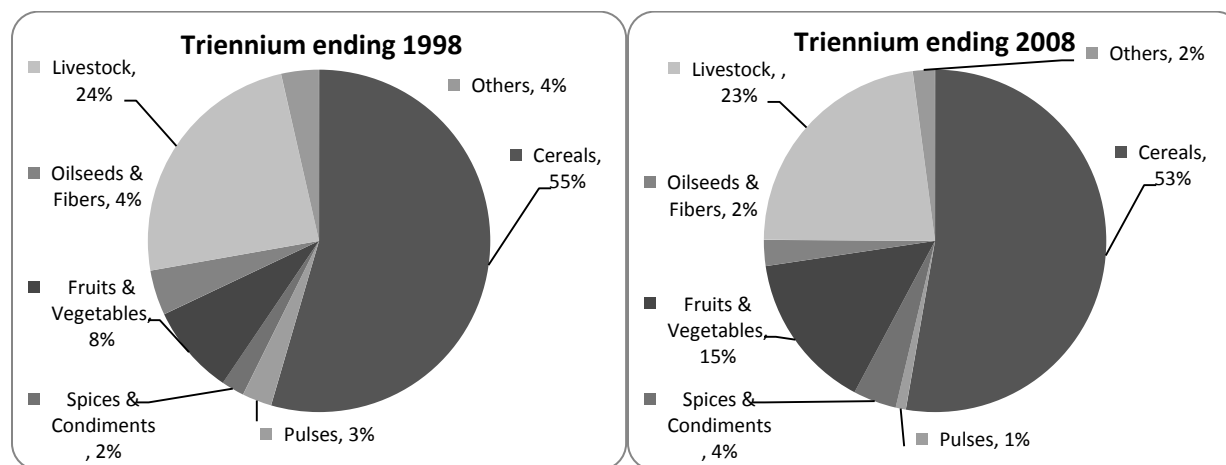
**Figure 2.2—Share of agriculture in total GDP and annual growth rate of GDP and agricultural GDP, 1991–2008**



Source: Asian Development Bank 2009.

The agricultural sector in Bangladesh is overwhelmingly cereal driven, especially by rice, which takes up a significant portion of the area under cultivation. Examining the share of various crop sectors in the total value of agricultural output (Figure 2.3) shows that from triennium ending (TE) 1998 to TE 2008 there has been only a slight decline in the share of the cereal sector, from 55 percent to 53 percent. The only sector that has shown a substantial increase in its share of the total output is the high-value fruits and vegetables sector, which has gone up from 8 percent to 15 percent. Barring this increase, other crop subsectors have not witnessed much change, and the overall structural makeup of Bangladesh’s agriculture continues to be dominated by cereals.

**Figure 2.3—Share of various sectors in gross value of agricultural output (percentage)**



Source: Food and Agriculture Organization 2010a.

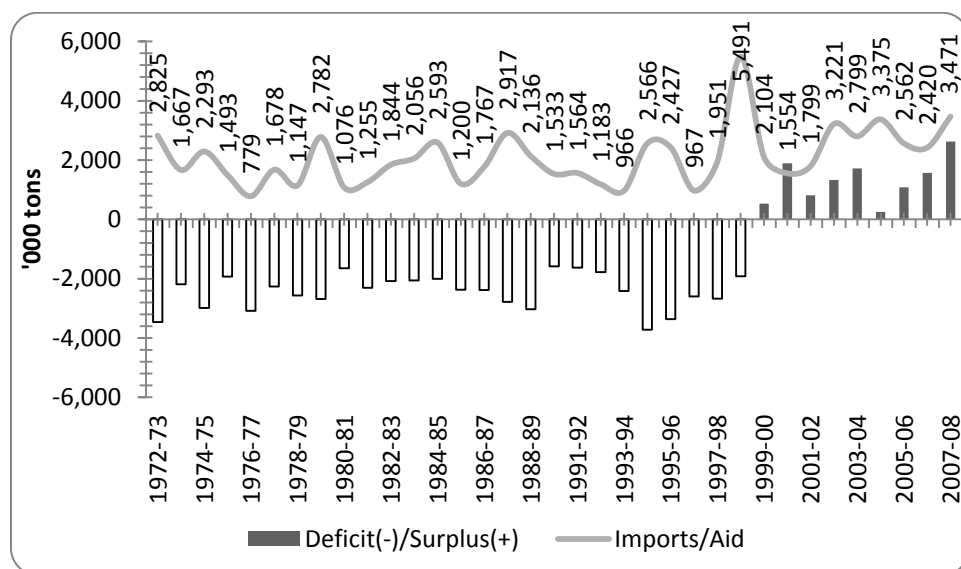
Notes: (1) Values based on local currency prevailing in the price reference period (1999–2001); (2) does not include fishery and forestry.

Even with the predominance of cereal crops, Bangladesh failed to achieve self-sufficiency in grains, and domestic production fell short of the national demand (normative) until fairly recently (Figure 2.4). Starting from the late 1980s, Bangladesh managed to achieve significant advances in rice production with the growth of rice in the *boro* season<sup>1</sup> (discussed in later sections). With this ramping up of production, Bangladesh’s grain production crossed the stipulated (normative) demand for the first time in the year 1999–00. However, to meet actual demand it appears that Bangladesh still depends upon imports of grain and also some amount of food aid even in the years since 1999–00 (Figure 2.4). Two possible reasons could explain this observation. First, the data shown here in Figure 2.4 portray only the imports and not the net imports, which is the difference between imports and exports. However, foodgrain exports from Bangladesh are limited to small quantities of high-value, fine-quality rice to the tune of 8,500 to 10,000 tons<sup>2</sup> (World Food Programme 2009). Therefore, it might be surmised that the net import quantities may not differ much from the the import quantities shown here. The second possibility is that the actual level of consumption is higher than the normative consumption. This could be due to the possibility that the former includes indirect or nonhuman demand, while the normative consumption refers only to direct or human demand. The sudden spike seen in Figure 2.4 for the year 1998–99 reflects the increased food aid from donors, given to tide over the crisis following the 1998 “flood of the century,” which affected more than two-thirds of the country and caused rice crop losses to the tune of 2.04 million tons (del Ninno 2001).

<sup>1</sup> Dry season rice grown during October–March is referred to as *boro*. There are two other rice seasons in Bangladesh: *aus*, which is sown in April–May and harvested in July–August, and *aman*, which extends from April–May to November–December.

<sup>2</sup> Throughout this paper tons refer to metric tons.

**Figure 2.4—Foodgrain surplus/deficit and foodgrain import/aid, 1972/73 to 2007/08**



Source: Food Planning and Monitoring Unit 2008.

Notes: (1) Foodgrain here consists of rice and wheat;

(2) Surplus/deficit is the difference between the total foodgrain requirement and the net domestic production;

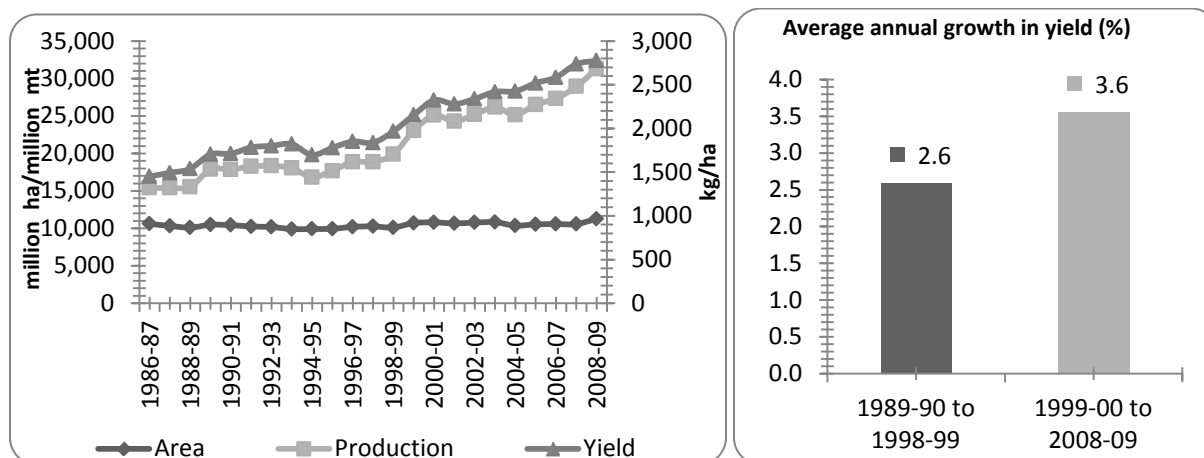
(3) Foodgrain requirement is calculated on the basis of the normative per capita requirement fixed at 453.66 grams per day per head; and

(4) Net domestic production is calculated by deducting 11.58 percent of the total production for seed, feed, and wastage.

### Trends in Cereal Production, Area, and Yields

Bangladesh’s agricultural sector is dominated by rice. Three seasons of rice crop are possible in Bangladesh, and nearly 75 percent of the total cropped area in the country comprises only rice. This area under rice has remained fairly constant, but total rice production has shown a steady increase on the back of increasing yield levels. Rice yields have increased from less than 1,500 kilogram (kg)/ hectare (ha) in 1986–87 to an average of more than 2,700 kg/ha by 2008–09 (Figure 2.5), while gross rice acreage has remained at around the 10 million ha mark. Consequently, production has more than doubled from around 15 million tons in 1986–87 to more than 31 million tons in 2008–09. Since 1999–2000, the growth rate in yield of rice has accelerated to 3.6 percent on average per annum, moving upward from 2.6 percent in the previous decade. This rapid growth in rice yields has been linked to the growth in tubewell irrigation and increasing use of high-yielding varieties and other inputs, particularly in the *boro* season (Asaduzzaman 2009, Hossain 2009). The policy drivers contributing to this will be examined later in this report.

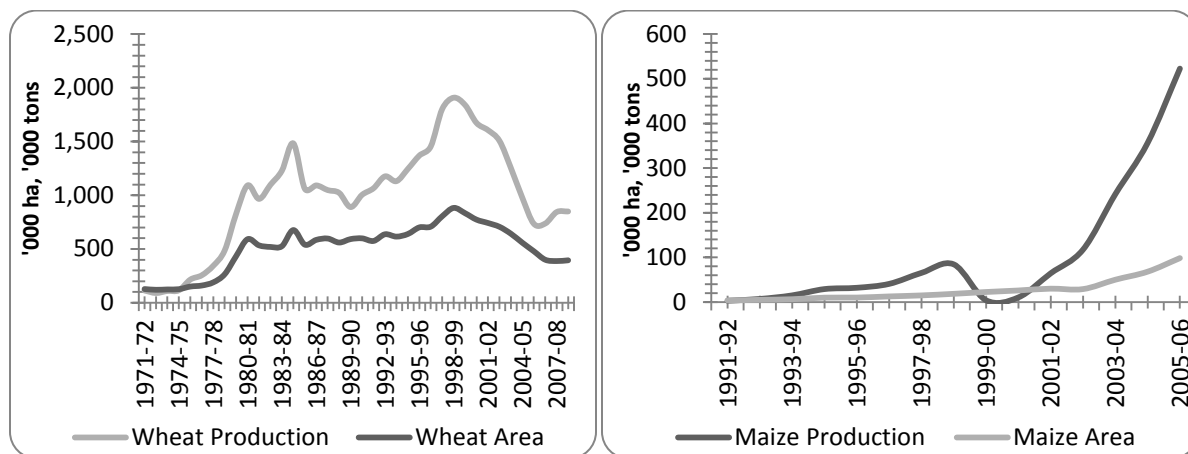
**Figure 2.5—Rice area, production, yield, 1986/87 to 2008/09, and growth rate in yield, 1998/90 to 1998/99 and 1999/00 to 2008/09**



Source: Ministry of Finance 2009.

The other two cereals—maize and wheat—occupy a relatively minor position in Bangladesh’s agriculture economy. Wheat, in particular, appears to be on a decline in recent years. Wheat area (production) has fallen from a high of 0.88 million ha (1.9 million tons) in 1998–99 to less than 0.4 million ha (0.85 million ha) by 2008–09 (Figure 2.6). A part of wheat acreage seems to have been replaced by rice, and recently by the rapid growth of maize.

**Figure 2.6—Wheat area and production, 1971/72 to 2008/09, and maize area and production, 1991/92 to 2005/06**



Sources: Ministry of Agriculture 2007, Bangladesh Bureau of Statistics 2010.

In contrast, maize in Bangladesh has been a huge success in recent years. There has been a rapid rise in yield levels similar to that observed in parts of South Asia. The trajectory of maize shows a remarkable change after 2000, with production jumping from a miniscule 4,000 tons in 1999–00 to more than 523,000 tons by 2005–06 (Figure 2.6). This dramatic rise in production is driven by the lucky combination of rising demand for maize from the poultry sector around this period; the emerging impact of earlier maize research and extension activities, aided by suitable climatic conditions in Bangladesh for hybrid maize; and the high rates of fertilizer use that had an impact on maize yields. Since 2000, maize has been responding to these drivers of growth and the area and production has been expanding at a fast pace, especially in the northwestern and west-central districts of Bangladesh (Ali et al. 2008).

### 3. INPUT SECTOR

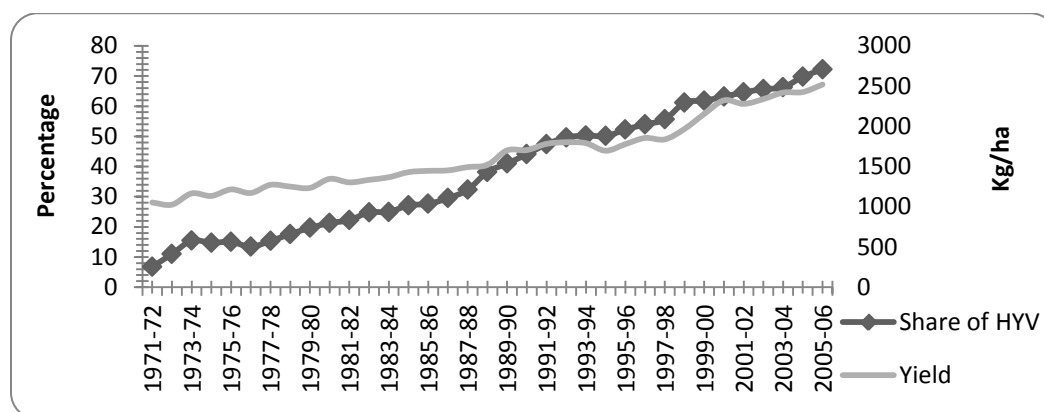
#### Seed Sector

##### *Current Status and Trends*

The development and delivery of quality-improved seed is an important strategy for increasing productivity and agricultural growth. In Bangladesh, since the end of the 1990s, the seed market has been expanding and the country has seen increasing private-sector presence in seed production and delivery systems (Hossain, Janaiah, Husain, and Naher 2001). Hossain et al. (2001), however, note that in spite of this expansion in seed markets, an efficient system was yet to develop in order to meet the need for high-quality seed among rice farmers.

Nevertheless, diffusion of improved varieties of seed, especially for rice, has been rapid in recent years. Hossain (2009, 10) notes that “modern agricultural technologies have spread rapidly in Bangladesh. Improved varieties are now used in three-fourths of the land under rice cultivation and their adoption has followed the development of the country’s irrigation infrastructure”. The share of rice acreage under high-yielding varieties (HYVs) has increased from just around 20 percent at the start of the 1980s to more than 70 percent by 2005–06. The increase in yield of rice (annual average across all seasons) has shown a similar trend, reaching nearly 2,500 kg/ha by 2005–06 (Figure 3.1). The increase in rice yields in Bangladesh has been fuelled by a host of factors, diffusion of HYVs being one of them.

**Figure 3.1—Share of rice area under HYV (percentage) and rice yield (kg/ha), 1971/72 to 2005/06**



Source: Ministry of Agriculture 2007.

In spite of this spread of modern seed varieties, the Bangladesh Seed Growers, Dealers, and Merchants Association (BSGDMA) estimates that domestic “improved” seed production meets only a small share of the demand (estimated indirectly, based on the total area under the relevant crop and recommended improved seed rate per unit area for that crop) in the market for quality, improved cereal seed. The rest of the demand is met through either imported seed or, mostly, the informal seed market. The Bangladesh Agricultural Development Corporation’s (BADC’s) estimate of the seed market for a subsequent period also reflects a similar domestic supply deficit, though the gap in supply-demand seems to have reduced in comparison to the earlier BSDGMA estimate. In the case of rice, supply of quality seed in 2007/08 was about 39 percent of the demand, up from 25 percent in 2005/06 (Table 3.1). Similarly, in the case of wheat, 55 percent of the demand for quality seed was met in 2007/08, while it was just 27 percent in 2005/06. In contrast, in the case of maize, almost the entire demand for quality seed is being met. It is interesting to note that the public sector dominates the seed sector in the cases of both rice and wheat, while in the case of maize it is the private sector that meets the bulk of the demand for quality seed.

**Table 3.1—Demand for and supply of improved cereal seed (in tons)**

	2005/06			2007/08		
	Rice	Wheat	Maize	Rice	Wheat	Maize
<b>Total demand</b>	313,955	72,000	3,300	306,840	70,800	5,000
<b>Total domestic supply</b>	77,664	19,051	3,233	118,500	39,216	4,970
<b>Public</b>	74,314	19,051	233	99,700	39,216	479
<b>Private</b>	3,350		3,000	18,800		4,500
<b>Supply as percent of demand</b>	24.7	26.5	98.0	38.6	55.4	99.4

Sources: Bangladesh Seed Grower, Dealer, and Merchants Association (BSGDMA) 2007 for 2005/06 and Bangladesh Agricultural Development Corporation (BADC) 2011 for 2007/08.

### ***Policies and Institutions in the Seed Sector***

The seed sector in Bangladesh has been dominated by the public sector, and the Bangladesh Agricultural Development Corporation (BADC), an autonomous corporate body under the Ministry of Agriculture (MOA) that is a major agricultural input supplier, continues to be the largest seed supplier. The legal framework underpinning the seed sector comes from the Seed Ordinance 1977, the Seed Amendment Acts 1997 and 2005, and the Seed Rules 1998. The legal, regulatory, and institutional mechanisms governing the sector have been drawn together in the National Seed Policy (NSP) of 1993. The NSP marked the beginning of liberalization in the seed sector and heralded the rise of private enterprises in seed production, import, and distribution. Table 3.2 provides an overview of the major legal, regulatory and institutional characteristics that make up the seed sector in Bangladesh.

The regulatory institutions governing the seed sector in Bangladesh include the National Seed Board (NSB), the Seed Wing of the Ministry of Agriculture (MOA-SW), and the Seed Certification Agency (SCA). The NSB, which comprises members from the ministry as well as the private sector, is the apex policy body. It drafts, reviews, and monitors the implementation of various facets of seed policy. The MOA-SW also deals with seed acts, rules, and regulations, but is also concerned with monitoring the seed supply-demand situation and seed import and administers the SCA, which is responsible for seed quality, testing, and certification. The MOA-SW also monitors seed dealers, agencies, and their activities. Together these three bodies cover most aspects of policy and regulation pertaining to the seed sector.

**Table 3.2—Legal, regulatory, and institutional setup of the seed sector in Bangladesh**

<b>Legal framework</b>	
<b>The Seed Ordinance 1977 The Seed Amendment Act (1997 and 2005)</b>	These form the major legal framework surrounding the seed sector in Bangladesh. The Seed Ordinance 1977 lays down the role and functions of the National Seed Board (NSB) and the Seed Certification Agency (SCA). The Seed Ordinance and the Seed Amendment Act regulate import and export of seed, determine the standards for quality of seed, and oversee the approval and registration of new varieties and the labeling of seed.
<b>Plant Quarantine Regulation (PQR) 1966</b>	As a signatory of various international laws, Bangladesh is committed to adhere to rules and regulations that prevent the introduction and spread of pests and diseases. Plant quarantine regulations in Bangladesh are governed by the “Destructive Insects and Pest Rules,” 1966, which was amended in July 1989. Under this, various rules exist for the “safe importation of plant products, including seed, into the country without creating obstacles to international agricultural trade and international transfer of germplasm.”
<b>National Seed Policy 1993</b>	The National Seed Policy was laid down with the objectives of (1) promoting balanced development of public and private-sector seed enterprises; (2) simplifying the import of seed and planting material; (3) providing training and technical support for seed stakeholders in topics related to seed production, processing, storage, and use of high-quality seed, and (4) monitoring, controlling, and regulating the quality and quantity of seed produced in Bangladesh.
<b>Seed Rules 1998</b>	The Seed Rules pertain to clarifying the functions of the NSB; the SCA and its seed inspectors are highlighted. These rules also provide a more detailed description of the seed regulatory framework and the procedures related to variety registration, field inspection, seed certification, and market control.
<b>Regulatory institutions</b>	
<b>Ministry of Agriculture—Seed Wing (MOA-SW)</b>	The Seed Wing, established in 1992, had the mandate to implement the newly adopted Seed Policy 1993. It is the nodal agency administering the Seed Certification Agency and is responsible for registering and monitoring seed dealers; developing and amending seed acts, rules, and regulations; and monitoring their implementation. It also has an extension role and is responsible for disseminating information on seed technologies and training courses for capacity development. Apart from its regulatory role, the Seed Wing is also responsible for monitoring seed production, import, distribution, and utilization within the country and for testing breeder seed, certifying seed, monitoring the seed market, and analyzing the demand and supply of seed in Bangladesh.
<b>National Seed Board (NSB)</b>	The National Seed Board (NSB), established in 1974, is the apex policymaking institution. It is a statutory body comprising 21 representatives from the official institutions and the private seed sector. It advises the government on various seed-related issues, such as development of the seed industry, seed ordinance, seed rules and policies, variety release and registration, seed standards, seed variety, and seed promotion.
<b>Seed Certification Agency (SCA)</b>	SCA, also established in 1974, is the statutory body overseeing seed certification and variety release. After the new Seed Policy, the role of SCA was expanded and it was entrusted to monitor seed quality control, testing, and enforcement of seed regulations. It carries out independent evaluation of the varieties of notified crops for the release by NSB and keeps records of quality and characteristics of various seed varieties.

**Table 3.2—Continued**

<b>Seed research, production, and distribution</b>	
<b>Bangladesh Agricultural Development Corporation (BADC)</b>	BADC is a public agency under the MOA. It is the largest seed producer and supplier in Bangladesh and engages approximately 50,000 smallholders as contract growers, 23 seed production farms, and 16 contract grower zones; oversees seed sales offices in all districts; and is connected with more than 1,000 registered private seed dealers. In recent years, expanding involvement of the private sector and nongovernmental organizations (NGOs) in seed multiplication has led to a reduction in the role of BADC.
<b>Bangladesh Agricultural Research Council (BARC)</b>	BARC, under the MOA, is the apex body of the National Agricultural Research System (NARS). The main responsibility of BARC is to coordinate, plan, and promote systematic agricultural research. BARC works in collaboration with the NARS institutes, as well as with the private sector and international research organizations.
<b>Formal Private Sector</b>	The National Seed Policy in 1993 triggered an increase in formal private-sector participation in the Bangladesh seed sector, and by 2005–2006 the amount of seed supplied by the formal private sector was estimated to be 14,551 MT. Although BADC is still the major supplier, especially for high-volume/low-profit seed for crops such as cereals, pulses, jute, and so on, the private seed companies have been playing an important role in the low-volume/high-value seed segment, including hybrid seeds of maize, rice, and vegetables. The formal private seed sector comprises both multinational companies and domestic seed enterprises. Despite this growth of the formal private sector, and the continuing presence of the public sector, informal sources (including farmers' own harvests and seed exchanges) are the largest of improved seed, including imported seed, in the country.
<b>Nongovernmental Organizations (NGOs)</b>	NGOs have begun to play an important role in seed supply in Bangladesh, with as many as 20 NGOs taking up seed production, marketing, and distribution (as both relief programs and commercial programs). These include the Bangladesh Rural Advancement Committee (BRAC), Grameen Krishi Foundation, Proshika, Rangpur Dinajpur Rural Service (RDRS), and Gono Kollan Trust.
<b>Consultative Group on International Agricultural Research (CGIAR) institutions</b>	Various NARS institutes under BARC have been collaborating with CGIAR research institutions. Bangladesh Agricultural Research Institute (BARI) has received support from the International Maize and Wheat Improvement Center (CIMMYT) in the development of varieties of maize and wheat, while the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) collaborated with BARI in the development of groundnut and chickpea varieties. The International Potato Center (CIP) has worked closely with BARI in the introduction and development of potato germplasm. BIRRI benefited from collaboration with the International Rice Research Institute (IRRI) in the releasing of new varieties of rice.

Source: Adapted from Bødker, Wulff, and Torp 2006.

### **Seed Research, Production, and Distribution**

Rice in Bangladesh, as mentioned before, has shown tremendous growth over the years. Along with the spread of irrigation and the increased use of fertilizer, the spread of high-yielding varieties (HYVs) has played an important role in promoting this rice revolution. The results of the decomposition of Bangladesh's rice output growth during 1981–2008 presented by Chowdhury (2010) delineate the area, yield, and cropping pattern effects on production growth.<sup>3</sup> This analysis finds that “pure yield effects

<sup>3</sup> Chowdhury (2010) uses the decomposition developed by Minhas and Vaidyanathan (1965), wherein the sources of production growth are decomposed in (1) an area effect, (2) a cropping pattern effect, (3) a pure yield effect, and (4) a set of interaction effects. Area effect refers to the contribution of changes in the total rice acreage to output growth. Cropping pattern refers to the shares of HYV and non-HYVs in the total area under rice. Yield effect refers to the contribution of changes in aggregate yields (over HYVs and non-HYVs) to production growth. There are four interaction effects here that include pair-wise

come through as the second-most important source of positive growth in output” after the cropping pattern effect (Table 3.3).

**Table 3.3—Decomposition of Bangladesh’s rice output growth, 1981–2008**

<b>Sources of growth</b>	<b>Contributions</b>	<b>Percent of total contribution to effects</b>
Pure acreage effect	-0.51	-1.50
Pure yield effect	16.31	48.34
Cropping pattern effect	20.62	61.13
Interaction between yield and crop pattern	-2.43	-7.22
Interaction between area and crop pattern	-0.29	-0.86
Interaction between area and yield	0	0
Interaction among area, yield, and crop pattern	0.04	0.12
<b>Total effects</b>	<b>33.73</b>	<b>100.00</b>

Source: Chowdhury 2010.

Although modern high-yielding varieties (HYVs) of rice were adopted as early as 1968, the rate of adoption remained low until 1975–76 (Husain, Hossain, and Janaiah 2001). The rapid diffusion of rice HYVs started to occur only after the mid-1980s, and it has been observed that this takeoff had a lot to do with the liberalization of policies regarding the import and distribution of other agricultural inputs, such as fertilizer and irrigation equipment (Hossain and Akash 1994). The spread of affordable technologies and the availability of various inputs seem to have paved the way for greater adoption of HYV seed. Along with the contextual factors promoting adoption, the spread of HYV seed also required the presence of government policies to foster the research, production, and distribution of quality seed. Rice seed research in Bangladesh started with the adaptation of the International Rice Research Institute’s IR8 variety for local conditions in the early 1970s. Since then, the Bangladesh Rice Research Institute (BRRI) has been involved in the development and release of numerous rice varieties with characteristics designed for particular seasonal use, yield potential, growth duration, flood tolerance, and so on (Jashim and Chowdhury 2001).

From the time that the NSP was put into place and private importation of hybrid seeds for rice, maize, and vegetables was legalized, the private sector has begun to play an important role in the seed market for the low-volume/high-margin segment. Jaim and Akter (2012), citing Talukder (2011), mention that presently 14 private-sector companies and NGOs are involved in the production and importation of hybrid seeds in Bangladesh. Nevertheless, the public sector is the mainstay of the cereals seed sector, especially in the case of rice, the most important staple cereal in Bangladesh.

Seed marketing and distribution is a combination of formal and informal systems. Within the formal system there exists the private sector, which comprises a large variety of players, including small farmer seed entrepreneurs, wholesalers/importers (many of whom are single proprietor operations), international seed companies, and joint venture companies, all of whom have to be registered as a seed dealer with the NSB. In addition, numerous NGOs (especially BRAC) have also started to play a major role in commercial seed activities. “Certified” seed and “Truthfully Labeled” seed in Bangladesh are primarily distributed by BADC seed sales centers and through private seed dealers (Bødker, Wulff, and Torp 2006).

In addition, a large informal setup exists for seed production and sales and seed exchange among farmers, very little of which is regulated. The extent of formal and informal seed markets differs according to the crop and seed varieties. Field survey findings by Hossain and Jaim (2009) (as cited in Jaim and Akter 2012) suggest that informal sources (own harvest and exchange with neighboring farmers)

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interactions between area, cropping patterns, and yields, and the interaction among all three.

account for well over two-thirds of the Bangladeshi-origin modern rice seed varieties and three-fourths of the Indian-origin modern rice seed varieties used by farmers. In the case of traditional rice varieties, this amount is an overwhelming 96 percent. In contrast, hybrid rice (grown by less than 2 percent of the farmers in this study) seeds are sourced mainly from the formal system. Thus, the bulk of the cereal seed market continues to be of the informal type.

### **Challenges**

The major issues facing the seed sector in Bangladesh have been discussed at length in several studies (Ahmed et al. 2011, Government of Bangladesh 2011, Jaim and Akter 2012). As mentioned above, despite the reforms in the seed sector and the subsequent growth of the sector, a large part of the seed market, especially for cereals, lies in the informal sector. This is, in effect, a reflection of insufficient domestic production of quality seed. As a result, the country is dependent on imports, which are usually priced higher than domestically produced seed, and also come with several other risks.

The most important risk with imported seed, indeed with seed trade in general, is their quality. The informal system of seed trade falls outside of any legal, regulatory, or quality-monitoring system. In fact, seed quality and certification remain a challenge even within the formal sector. Based on interactions with farmers, Ahmed et al. (2011) pointed out that farmers preferred seed from the public sector (BADC) because of their quality certification, but often they are unable to get adequate amounts of certified seed. Seed purchased from the private sector are typically more costly because the private-sector seed suppliers do not receive subsidies similar to the public sector seed producers (Jaim and Akter 2012). Besides, seed sold by private traders are often of unknown origin and of suspect quality because the SCA and other concerned government agencies do not have sufficient capacity to monitor and regulate these traders. Ahmed et al. (2011) also point out the lack of any mechanism for consumer feedback, an infrastructure for quick assessment of seed quality, and a system of establishing accountability of seed dealers. In the context of imported seed, it has also been noted that there is an “urgent need for a strategy and action plan for the update of the import and export regulations (for example, updating of the National List of Varieties and Plant Quarantine Regulations) to make the seed industry more flexible in their adoption to the expanding international and national seed trade market” (Bødker, Wulff, and Torp 2006).

As mentioned above, the NSP and subsequent legislations lay down the government’s objectives on seed. Although the seed sector has been opened up to the private sector, there is not much clarity in the legislations about the overall strategy for the seed sector and the balance of play between the public and private sectors. As a result, there are differences in the way the public and private sectors perceive and interpret their respective roles (Ahmed et al. 2011). Most private seed companies confine themselves to trading in seed, sourcing the seed from the public sector and through imports, rather than being involved in research or production of seed (Jaim and Akter 2012). This lack of clarity in the policy is compounded by insufficient information on the size and nature of the seed market for different crops, which prevents effective participation of the private sector. Other constraints faced by the private sector include deficiencies in the size and quality of their technical personnel, inadequate support from the government for establishing research facilities, and the lack of appropriate legal and regulatory systems for protecting intellectual property rights.

Farmers in Bangladesh are mostly resource poor and their traditional practice is to store seed on their farms. While this is helpful in normal times, natural disasters such as storms and floods often ruin their harvests and farm seed stores. In such situations, community seed banks have a critical role to play in protecting and promoting the livelihood of these small farmers by reducing seed costs. Establishing community seed banks, however, requires supporting farmers to help produce high-quality seed, develop community infrastructure for seed storage, and provide information on production and storage of seed through appropriate extension mechanisms (Ahmed et al. 2011). Here the role of women in seed processing and preserving must be recognized. Presently, women involved in seed processing and preservation derive their information from male members of the family. Their involvement in community seed banks can be enhanced with appropriate policies and extension mechanisms (Jaim and Akter 2012).

Cultivation of hybrid rice in Bangladesh began in 1998, though research on hybrids started five years prior to that. Of the 85 hybrid rice varieties presently cultivated in the country, 79 are imported varieties (Jaim and Akter 2012, citing Talukder 2011), highlighting the weaknesses in the domestic seed research and seed production systems. Spread of hybrid rice, however, has not been as dramatic as the other high-yielding varieties, despite the lower seed requirements for hybrid rice and the higher productivity level, due to consumer preferences and the fact that most resource-poor farmers cannot afford to buy hybrid rice seed (Ahmed et al. 2011).

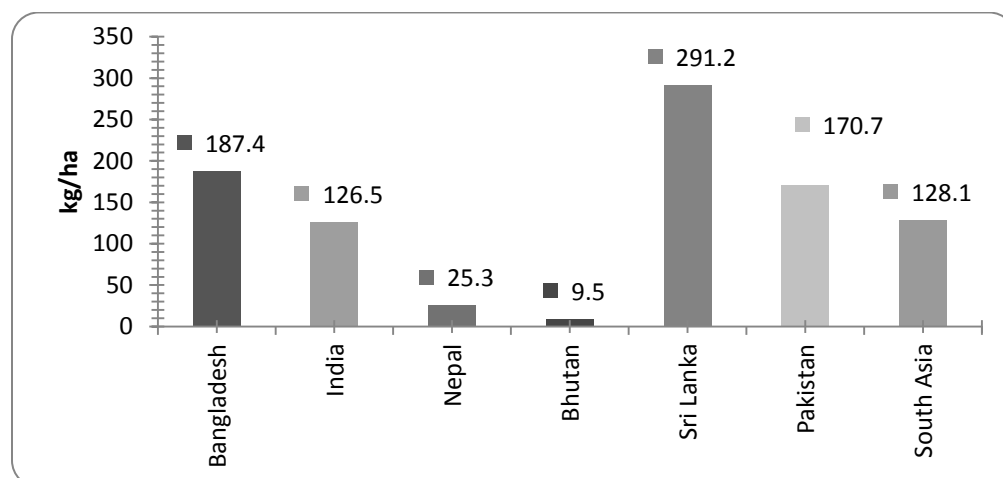
Agriculture in Bangladesh faces several challenges. Rice, the main staple crop of the country, in particular is increasingly subject to environmental challenges such as salinity, flash flood submergence, droughts, water stress during the dry (*boro*) season, and climate change. These are new and emerging challenges that the seed research system (both public and private sector) has to address to ensure that food security of the country does not suffer much. Here, biotechnologies offer exciting possibilities for developing new varieties that can better withstand different environmental stressors. The challenge is to gear up public and private agricultural research to meet the needs of the country.

## Fertilizer and Agrochemical Sector

### Current Status and Trends

Bangladesh's fertilizer use has been on the rise, and in terms of intensity of use (kg/ha) it ranks relatively high in comparison to other South Asian countries, except for Sri Lanka (Figure 3.2). By 2002, nearly 87 percent of farmers used fertilizers, and among farmers in irrigated villages almost 100 percent of the farmers reported some fertilizer use. Total fertilizer use in the country in 2007/08 was about 4.1 million tons, up from 1 million ton in 1983/84. Use of urea, phosphate, potash, gypsum, zinc sulfate, and other micronutrients have all shown a rise during this period, with urea being the most important one, accounting for 67 to 69 percent of total fertilizer use (Jaim and Akter 2012). Fertilizer input was an important constituent of the high-input/high-output agricultural practices revolving around HYVs. Chemical fertilizers were found to account for 18 to 20 percent of the total expenditure of HYV crop production (Khondker et al. 2002).

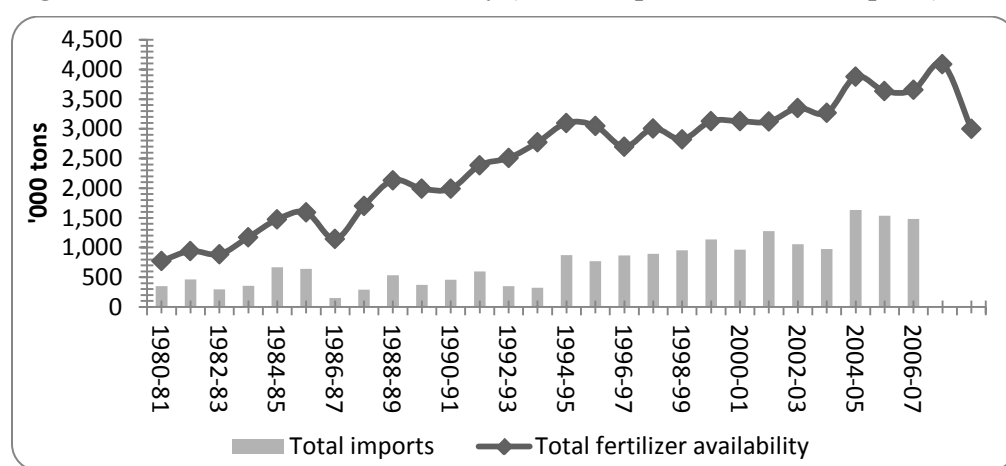
**Figure 3.2—Fertilizer use intensity across South Asian countries (kg/ha of arable land), triennium ending (TE) 2007**



Source: World Bank 2009.

The spread of chemical fertilizer use was a result of improving procurement, distribution, and availability across the country (Chowdhury, Farid, and Roy 2006). Since the beginning of the 1980s, both domestic production and imports have been ramped up and total availability has shown a consistent increase, except for a steep drop recently in 2008–09 (Figure 3.3). There has been a spurt in imports, particularly after 1993–94, around which time the fertilizer markets were completely liberalized and public subsidies completely removed. The country produces urea, triple super phosphate (TSP), and single super phosphate (SSP), but the domestic production of these fertilizers is mostly insufficient to meet the demand, and the gap is met through imports (Jaim and Akter 2012). As of 2009, Bangladesh had an installed capacity to produce annually 2,895,700 tons of urea (seven plants), 10,000 tons of ammonium sulfate (one plant), 489,600 tons of diammonium phosphate (DAP) (two plants), 697,000 tons of TSP equivalent (one plant), and 150,000 tons of SSP (one plant in the private sector) (Quader 2009). The country lacks capacity to produce potash fertilizers.

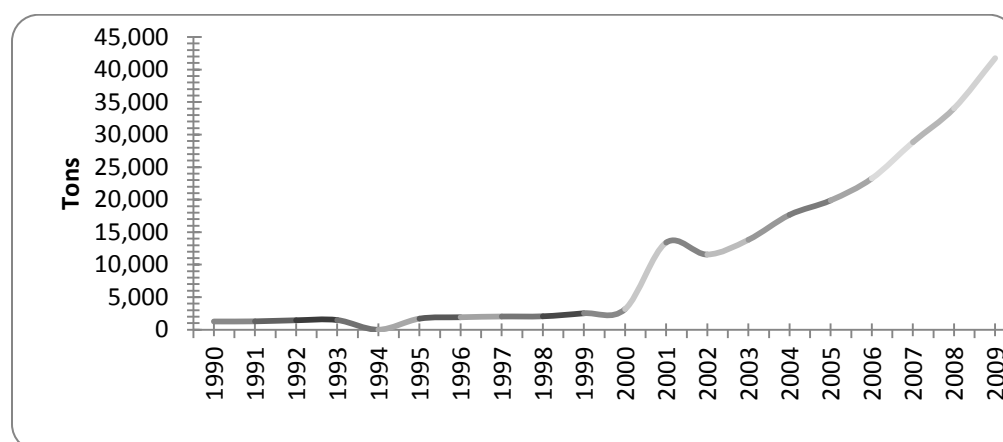
**Figure 3.3—Total fertilizer availability (domestic production and imports), 1980/81 to 2008/09**



Source: Ministry of Agriculture 2007.

The major constraint affecting indigenous fertilizer production is the availability of feedstock, which in the case of urea is accentuated by the vintage of the manufacturing units. Natural gas is the feedstock for the urea plants in the country. The seven urea plants in the country are fairly old, having been established between 1960 and 1996. The age of the urea plants raises the feedstock requirements. For instance, the oldest urea plant in the country requires 1,670 cubic meters ( $m^3$ ) of natural gas per ton of urea, compared to the natural gas requirement of 700  $m^3$  per ton of urea for modern plants (Quader 2009). Obviously, there is tremendous scope for efficiency improvement through investments in new plants. In the case of SSP, even though the private-sector plant was set up only in 2005, production could not commence even by 2009 due to the unavailability of elemental sulfur, phosphate rock, and phosphoric acid in the country. Similarly, unavailability of phosphoric acid has been a constraining factor preventing the two DAP plants that were built in late 2000 from reaching full capacity utilization (Quader 2009). The use of other agrochemicals, such as insecticides, herbicides, and fungicides, has shown rapid growth, especially after 2000 in Bangladesh. The total pesticide consumption has more than tripled, from around 11,500 metric tons in 2002 to more than 41,000 metric tons by 2009 (Figure 3.4). Nearly 80 percent of pesticide consumption is made up of insecticides. The majority of pesticide use was found to be associated with the cultivation of rice, followed by their use in vegetable cultivation (Parveen and Nakagoshi 2001). A pesticide use survey carried out by the World Bank of 820 *boro* rice, potato, bean, eggplant, cabbage, sugarcane, and mango growers in Bangladesh found that more than 47 percent of the farmers used more pesticides than was required to protect their crops (World Bank 2007). This has worrisome implications for health and environmental impacts.

**Figure 3.4—Consumption of pesticides in Bangladesh, 1990–2009**



Source: Food and Agriculture Organization 2010a.

A 2003 study (Sanzidur 2003) based on data from 21 villages, found that cultivation of traditional and modern rice varieties, potatoes, spices, vegetables, and cotton drove pesticide use among farmers. Also, interestingly, the study indicated that farmers in Bangladesh seemed to treat pesticides as substitutes for fertilizers (as indicated by the positive influence of fertilizer prices on pesticide use). Land ownership and access to agricultural credit were also found to be positively correlated with pesticide usage among farmers.

### ***Policies and Institutions in the Fertilizer and Agrochemical Sector***

Similar to the seed sector, the fertilizer, pesticide, and agrochemical sectors were largely controlled by the Bangladeshi government all through the 1970s. Procurement and distribution were under the virtual monopoly of a parastatal (here, too, the role was played by BADC); a fertilizer subsidy program was administered and private trade was heavily regulated (Barkat et al. 2010).

Pesticides were the first to be deregulated, followed by the deregulation of the fertilizer sector. Both of these sectors were deregulated beginning in the mid-1980s, well before the deregulation of the seed sector. Government interventions were gradually dismantled, and space was created for a competitive fertilizer market. Fertilizer subsidies were completely removed by 1992 and by the mid-1990s the process was almost complete, when the role of the public sector was almost entirely done away with in the fertilizer sector. Table 3.4 traces the contours of the changing policy regime in the fertilizer sector in Bangladesh. The transition to an open market system by the mid-1990s was seen by many observers as having led to an improvement in the overall efficiency in transportation, storage, and distribution of fertilizers as well as translating to better availability of fertilizers at the farm level. It also led to a lowering of the subsidy burden on the government.

**Table 3.4—Changing fertilizer policy in Bangladesh**

Period	Policy Regime/Changes
<b>1960s– 1970s</b>	In response to inadequate supply and progress in the spread of fertilizer, the public sector was given complete control over fertilizer procurement and distribution, with the responsibility of procuring fertilizer from both domestic and external sources and distributing it right to the level of the small administrative unit ( <i>thana</i> ) vested solely with the BADC. Under this “old marketing system” (OMS), the distribution of fertilizer was through Thana Sale Centers (TSCs) at subsidized prices. BADC-registered dealers were also allowed to lift fertilizer from TSCs and sell to farmers at regulated prices, for which a commission was paid to them.
<b>1970s– 1980s</b>	The OMS was found to have a number of inefficiencies, especially with regard to appointment of dealers, erratic supply, inadequate storage, and skewed incentives for dealers and farmers. Beginning in 1978, efforts were made to improve the system under a series of measures referred to as the “new marketing system” (NMS). Although the overall procurement operations remained a public sector monopoly, significant changes were introduced in the distribution chain, with the aim of improving efficiency and bringing in competitiveness and private participation. BADC withdrew from retail sales and instead concentrated only on maintaining wholesale centers at various strategic points in the country. Restrictions on fertilizer movement across the country and the cumbersome registration process for retailers were eased. Starting in 1983, fertilizer price at the retail level was also decontrolled.
<b>1990s</b>	Although the NMS had enjoyed major success in many aspects, various constraints remained and meeting farmer demand during peak season continued to be a problem. Thus, policy started to shift toward an open market system. By 1989, direct lifting of fertilizer from domestic production centers as well as ports was allowed in response to a urea crisis that occurred despite there being large stocks present. In 1992, the government excluded fertilizers from the list of restricted imports, paving the way for the private sector to import fertilizer. By December 1992, the subsidy on fertilizers was withdrawn completely and import and distribution of fertilizer made open.
<b>1990s– 2000s</b>	Fertilizer crises at various points in time (initially in 1995, followed by more recent setbacks in 2005, 2007, and 2008) resulted in partial restoration of government control over the fertilizer market. In recent years, following the promulgation of a new dealership policy in 2008 and 2009 in the wake of a fertilizer supply crisis and price spikes, the fertilizer distribution system was revamped and some amount of subsidy was also introduced (though the stated aim of the subsidy was more toward balancing the use of various fertilizers to maintain soil health). The fertilizer distribution network is once again composed of appointed/licensed dealers who are limited to selling in a particular designated area, with the objective of ensuring effective fertilizer distribution all across the country.

Source: Adapted from Barkat et al. 2010.

The period of open market system for fertilizer has witnessed a number of problems related to short-term price spikes, failure in quality control, and so on (Barkat et al. 2010). Adulteration of fertilizers became so rampant that in 1996 some control measures were reintroduced. There have been several instances of inadequate availability of fertilizers, especially urea, and frequent price hikes. These episodes, often described as fertilizer crises, were often due to the changing supply situation domestically, high prices in the world markets, and the market power of fertilizer dealers. These crises in meeting fertilizer demand have resulted in the government undertaking various changes to the policy regime, including a return to subsidies and the regulation of retail trade. The government has experimented with several schemes for fertilizer distribution, such as the *slip system* introduced in 2007. In the *slip system* farmers were issued slips by local agricultural officers, which would then need to be presented to the dealer in order to obtain a certain quantity of fertilizer allotted to them. Presently, the marketing of fertilizer involves a network of dealers and subdealers registered with the Bangladesh Chemical Industries Corporation (BCIC), which has a mandate to sell fertilizer in designated geographical areas, but with no quota restrictions on the quantum of fertilizers that are sold to farmers (Jaim and Akter 2012).

The policy landscape surrounding pesticides and other agrochemicals in Bangladesh follows a similar trajectory, as traced by the fertilizer and seed sectors. Pesticides were introduced in Bangladesh around the mid-1950s; in an effort to popularize their use, pesticides such as dichlorodiphenyltrichloroethane (DDT) and benzene hexachloride (BHC) were distributed free of cost to farmers by the government until 1973. These measures encouraged widespread use of pesticides, until 1974, when the subsidy was reduced to 50 percent. Then, in 1979, following the complete withdrawal of subsidies on

pesticides, usage started to decline (Islam 2000). Pesticide usage started to pick up in the late 1980s as a result of the increasing penetration of HYV seed and the spread of input-intensive *boro* rice (Islam 2000).

The main policy governing pesticide use, manufacture, and regulation was the Pesticide Ordinance, promulgated in 1971. The ordinance had provisions to regulate the import, manufacture, formulation, distribution, and use of pesticides. Later, the ordinance was amended in 1980, in keeping with the public policy shift toward private-sector participation, and provisions were made to license private-sector enterprises and govern the trade in pesticides, which was now largely in private hands. Pesticide Rules (1985) was put in place to facilitate the enforcement of the provisions laid down in the earlier ordinance. The Pesticide Ordinance extended to all pesticides, whether used for agriculture, public health, or any other purpose. The Ministry of Agriculture through the Plant Protection Wing of the Department of Agricultural Extension (DAE) was the overall agency responsible for its implementation.

With increased pesticide usage, there has been heightened concern of the unfavorable environmental and health impacts of these compounds. As a result, in 2010, an amendment to the Pesticide Rules (1985) was passed by the government. This amendment will allow the registration of commercial production and marketing of biochemical pesticides, including its distribution and use (Katalyst 2010), and provides a thrust for the development of integrated pest management (IPM) practices in Bangladesh.

### **Challenges**

The fertilizer sector in Bangladesh faces several challenges posed by the continuing tensions between a liberal, market-oriented system and the need to maintain steady supplies of good-quality fertilizers at reasonable and stable prices. A recent survey on fertilizer demand and usage among farming households in Bangladesh by Barkat et al. (2010) found a large proportion of farmers experiencing a fertilizer deficit, even if they were able to access it. They noted that “none of the fertilizers can meet more than 40 percent of the requirement of the households which use it,” and even in the case of urea “around 60 percent of households are suffering from urea deficit.” The study identified high prices, lack of timely supply at peak demand periods, and in some regions supply being handicapped by lack of transportation as the reasons for this large-scale deficit in fertilizer use.

As mentioned earlier, with the transition to private marketing of fertilizers, the quality of fertilizers available in the market has always been an issue of concern. Despite attempts to regulate fertilizer quality through district committees, high rates of fertilizer adulteration continue to be a fact (Ahmed et al. 2011). One reason for this is the lack of trained staff, resources, and fertilizer testing facilities. This situation is compounded by the lack of a national-level institution responsible for monitoring the quality of fertilizer imports and domestic production.

With frequent price spikes in recent years, the benefits conferred by the shift to a completely open market system have been dampened, as noted in the survey findings above. Consequently, the government has experimented with putting back in place a subsidy and government-appointed dealer policy, while leaving the procurement and distribution activities largely in the hands of the private sector.

One aspect of the high price of fertilizer is the relative price of urea and non-urea fertilizers. In general, non-urea fertilizers, most of which are imported, have witnessed huge spikes in prices due to world market conditions. As a result, import costs have risen sharply. Because this could affect farmers’ ability to afford the use of fertilizers, the government reintroduced subsidies for imported fertilizers in 2007. Subsidies were raised once during the *boro* season of 2009 and again during *boro* 2012. Although the government’s stated aim is to reduce the cost of production for farmers, doubts have been raised about the efficacy of these subsidies. The points of contention are (1) the real beneficiaries of these subsidization policies (farmers versus fertilizer producers/traders) and (2) the question of balance between urea and non-urea fertilizers. The present universal fertilizer subsidies, it has been argued, do not ensure that benefits of the subsidies are passed on fully to the farmers. Thus, targeted fertilizer subsidies have been suggested for ensuring that the benefits reach farmers, resulting in improved productivity (Ahmed et al. 2011).

The second major apprehension about the fertilizer subsidy regime is that it could cause an imbalanced use of fertilizer, as has happened in neighboring India, with adverse consequences for soil nutrient balance and soil health. Tweaking price policies alone is, however, insufficient to ensure that farmers use different fertilizers in a balanced manner. Better farmer education on the needs for frequent soil testing and calibrating the use of different fertilizers as per actual soil conditions is critical here (Ahmed et al. 2011). The government, too, recognizes the need for ensuring soil fertility and seeks to promote the efficient and balanced use of fertilizers (Government of Bangladesh 2011). Toward this it proposes to establish new and strengthen existing soil testing laboratories so that fertilizer application is aligned with actual soil conditions.

In the context of soil health, the role of organic manure is well known. Use of organic manure in Bangladesh is, however, low and there is some scope to increase its use (Jaim and Akter 2012). However, organic manure has some disadvantages because of high labor and transport costs. There is also the possibility of toxic content and municipal waste in untreated manure. Bioslurry from biogas plants has been suggested as an environmentally friendly and nonhazardous organic fertilizer. It has been reported that in 2006, there were 25,000 biogas plants, producing about 200,000 tons of bioslurry, which is equivalent to 9,000 tons of urea, plus 25,000 tons of triple super phosphate and 3,200 tons of muriate of potash and other fertilizers (Islam 2006, as cited in Jaim and Akter 2012). This study also mentioned that Bangladesh has the potential to have as many as 4 million biogas plants, which could in principle solve the fertilizer crisis. Although the ultimate potential is yet to be firmly established, there is nevertheless scope to increase the number of biogas plants. This requires not just investments in the physical infrastructure but also enhancing education and awareness to develop a culture of collecting organic wastes, as well as training in proper handling and maintenance of the equipment.

In recent years, the various detrimental effects of pesticide use on the environment and health (due to overuse and improper handling) have become a prime concern. Some of these hazards were highlighted as early as 1997, when the human exposure level in Bangladesh was found to be 0.02 mg/kg/day, much higher than the permissible level of 0.005 mg/kg/day (Rahman and Alam 1997). More recently, pesticide poisoning was found to be a leading cause of death in Bangladesh according to the 2009 Health Bulletin. This annual study of the government of Bangladesh, which compiled health statistics from 2008, recorded 7,438 pesticide-related poisoning deaths at more than 400 hospitals nationwide among men and women aged 15–49 (IRIN 2010). These concerns have prompted the policymakers in Bangladesh to explore alternatives to chemical pesticides and encourage the manufacture and use of organic and biopesticides as a means of crop protection.

## **Irrigation**

### ***Current Status and Trends***

Located at the confluence of the Ganges, Brahmaputra, and Meghna (GBM) river basins, Bangladesh lies almost entirely in the deltaic zone of these three rivers (Food and Agriculture Organization 2010b). Together this river system has one of the highest discharges in the world. Of the total water withdrawals in the country, nearly 88 percent is estimated to be for agricultural use (Food and Agriculture Organization 2010b). Nearly 73 percent of the land having irrigation potential is already equipped for irrigation, which translates to about 58 percent of the cultivated area (Table 3.5). The area equipped for irrigation has grown at about 2.3 percent per annum in the period 1995–2008.

**Table 3.5—Irrigation potential and actual area irrigated in Bangladesh, 2008**

Irrigation potential	6,933,000 ha
Total area equipped for irrigation	5,049,785 ha
As % of irrigation potential	73%
As % of cultivated area	58%
Average increase per year over 1995–2008	2.30%

Source: Aquastat 2010.

In terms of sources of irrigation, in 2008, approximately 21 percent of the total water withdrawal was estimated to be from surface water sources and the remaining 79 percent from groundwater. Over time the share of surface water irrigation has been declining. It was around 41 percent during 1981–82 (Rahman and Parvin 2009). Surface water irrigation is mainly undertaken through the use of low-lift pumps (LLPs), canals, and traditional means (such as the *dhone* and swing basket). In 2008, of the 21 percent irrigated by surface water, the major means of irrigation was through the use of LLPs, while less than 3 percent of the irrigation was through means of gravity flow canals (Table 3.6).

**Table 3.6—Irrigation using surface water and groundwater by different modes, 2008**

Mode of irrigation	Number of equipment	Area irrigated (ha)	As % of total irrigated area
<b>Surface water irrigation</b>			
Low-lift pump	138,630	903,867	17.90
Gravity flow canals		138,803	2.75
Traditional method		19,044	0.38
<b>Subtotal</b>	<b>138,630</b>	<b>1,061,714</b>	<b>21.02</b>
<b>Groundwater irrigation</b>			
Deep tubewell	31,302	785,680	15.56
Shallow tubewell	1,304,973	3,197,184	63.31
Manual and artesian wells		5,207	0.10
<b>Subtotal</b>	<b>1,336,275</b>	<b>3,988,071</b>	<b>78.98</b>
<b>Grand total</b>	<b>1,474,905</b>	<b>5,049,785</b>	<b>100.00</b>

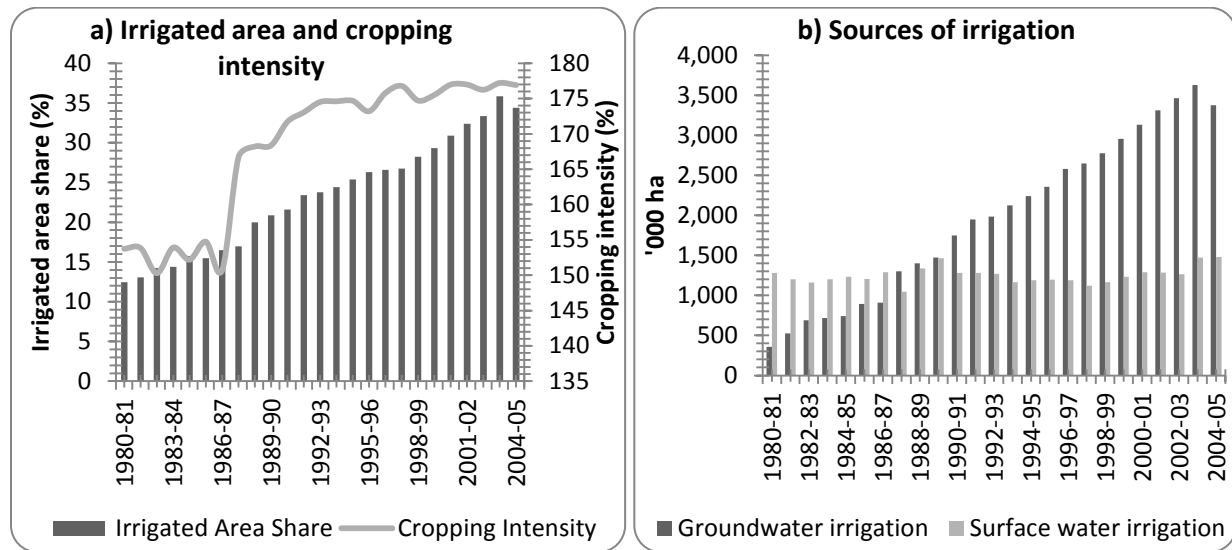
Source: Aquastat 2010.

Groundwater irrigation is carried out through means of deep tubewells (DTWs), shallow tubewells (STWs) and hand tubewells. The bulk of irrigation (more than 63 percent of the total irrigated area) is owing to the use of STWs (Table 3.6). The growth of STWs has in fact been the single most important factor driving irrigation growth in Bangladesh (Hossain 2009, Rahman and Parvin 2009). STWs took off rapidly from the mid-1980s onward, and government policy has been the driving force in their promotion. Also, their suitability to the existing socioeconomic conditions owing to their low investment cost, easy installation, easy maintenance, and feasibility for sharing among small groups of farmers made them convenient for small landholding owners.

The diffusion of STWs and consequent expansion in groundwater irrigation led to a jump in the cropping intensity in the country. A clear upward swing in cropping intensity is visible from 1986–87 onward (Figure 3.5a), corresponding to the jump in groundwater-irrigated area. Surface water irrigated area, on the other hand, has largely been on the decline (Figure 3.5b), except for the couple of years leading up to 2004–05. It has been argued that the growth of STWs played an important role in the spread of *boro* rice, which has proven critical in meeting Bangladesh's food security needs (Hossain 2009, Rahman and Parvin 2009). The increase in cropping intensity observed in Figure 3.5a has largely to do

with these phenomena of increasing acreage being brought under *boro* rice cultivation. Nearly 90 percent of *boro* rice, being the dry season crop, receives irrigation. The importance of *boro* rice to the overall rice supply in Bangladesh can also be gauged from the fact that since the 1980s onward the *boro* season has come to replace the *aman* season as the largest contributor to annual rice production (Figure 3.6).

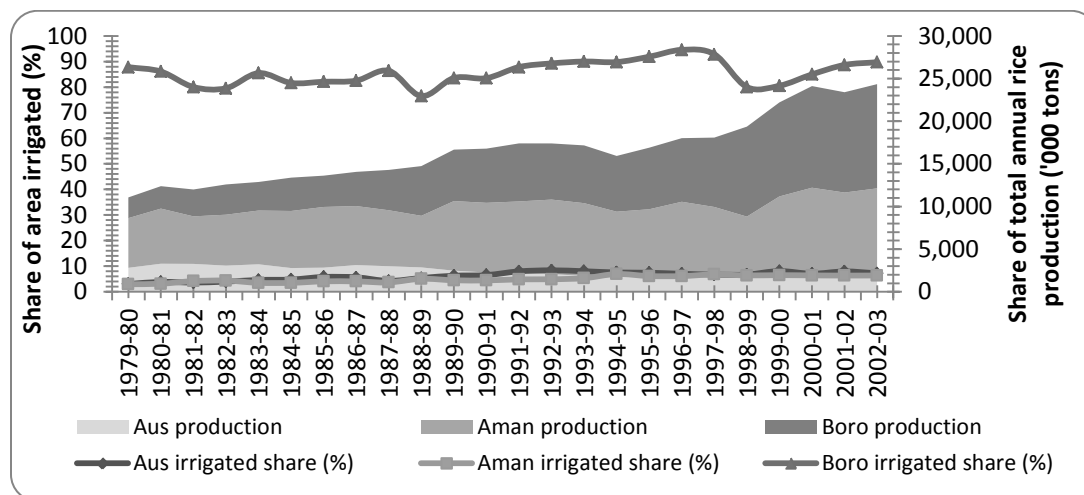
**Figure 3.5—Irrigated area share, cropping intensity, and irrigation by source, 1980/81 to 2004/05**



Source: Ministry of Agriculture 2007.

Note: Irrigated area share is defined as total irrigated area/total cropped area; cropping intensity is defined as net cropped area/total cropped area.

**Figure 3.6—Season-wise share of irrigated area in total cropped area for rice and season-wise rice production, 1979/80 to 2002/03**



Source: Ministry of Agriculture 2007.

## ***Policies and Institutions in the Irrigation Sector***

The shifts in the policy regime governing the irrigation sector in Bangladesh, particularly with respect to the spread of irrigation equipment, followed a very similar trajectory as that seen in the case of the seed and fertilizer sectors. Until the late 1970s, the procurement, installation, distribution, and management of irrigation equipment were controlled by parastatals, with various subsidies in place, as in the case of other agricultural inputs.

Various inefficiencies along the supply chain as well as in the management and utilization of irrigation equipment forced a review of government policy. Starting in 1979, the government undertook a process of privatization, albeit in a gradual and step-wise manner. Along the way, the government even rolled back the liberalization policy, before finally opening up completely in 1988–89. Hossain (2009) provided a detailed description of the policy changes that took place en route to opening up the irrigation equipment market, which set the ground for the rapid spread of STWs in Bangladesh. Table 3.7 (adapted from Hossain 2009) provides an overview of these policy changes in the irrigation sector.

**Table 3.7—Public policy changes in the irrigation sector**

<b>Year</b>	<b>Policy</b>
<b>1961</b>	BADC initially owned, operated, and maintained LLP sets and provided water to farmers on a flat charge on the basis of land area, and then began to rent LLPs to farmers on an annual basis, along with a 75 percent subsidy on fuel.
<b>1962–66</b>	The Bangladesh Water Development Board (BWDB) installed and operates 380 DTWs with a large capacity and with 100 percent subsidy for farmers. Managing large farmer groups was a problem, and experimenting with smaller capacity DTWs was started, found successful, and replicated across the country by the Bangladesh Rural Development Board (BRDB).
<b>1972–75</b>	BADC started to import and rent STWs to farmers' organizations and then shifted to selling STWs to individual farmers with the help of soft loans through banks, and until the late 1970s procurement, installation, distribution, and management of the irrigation system was entirely under the onus of parastatals, such as the BADC, BWDB, and BDRB.
<b>1979</b>	With increasing subsidy burden and growing inefficiencies in the parastatals as well as farmer groups managing the tubewell, policy shifted toward increasing private-sector participation. The private sector was allowed to import and distribute STWs, and credit facilities from commercial banks and the specialized Bangladesh Krishi Bank (BKB) were extended to enable farmers to purchase irrigation equipment. The private sector also started to make inroads in the repair and maintenance of equipment.
<b>1980–83</b>	Import duty on STW sets was reduced to 15 percent, and the BADC stopped renting LLPs and instead started to sell new and used LLPs to farmers' cooperatives. Privatization measures continued but subsidies for spare parts and repairs were still in place, hindering the spread of the local repair and maintenance market. Despite this, some private-sector manufacturing of pumps started.
<b>1983–87</b>	Bangladesh experienced a severe drought in 1983, with groundwater levels dropping especially in the northern districts. In response, there was a rollback of the liberalization process, which included banning the sale of STWs in 22 northern subdistricts; a stay on the imports of small diesel engines and controls and standardization of permitted engine brands; the formulation of the Groundwater Management Ordinance, laying down spacing requirements for tubewells; and the reduction in agricultural credit outlay. As a result growth of minor irrigation equipment usage slowed and remained stagnant over 1985–1987.
<b>1988–89</b>	Following a change of leadership at the agricultural ministry, the reform process was put back in motion. The ban on small engine imports was removed, import duties were eliminated, and standardization requirements were withdrawn. As a result, the private sector started to import cheap STWs from China and South Korea on a large scale, and STWs of various brands and sizes started to proliferate in the countryside.
<b>1990</b>	BADC started clearing out its stock of irrigation equipment and more or less withdrew completely from the STW market. The market for engines, pumps, and spare parts started to grow rapidly, and private-sector participation in repair and maintenance works spread all over the country.

Source: Adapted from Hossain 2009.

From an institutional point of view, the apex body for policymaking, planning, and management of water resources in the country is the Ministry of Water Resources (MoWR). The activities of the MoWR are guided by the National Water Policy (1999), under which it is entrusted with the responsibility for determining bulk water allocations among various sectors; regulating, conserving, and maintaining ground and surface water resources; formulating institutional reforms; developing the legal framework for establishing water user rights over ground and surface water resources; and providing contingency planning for managing water flows during droughts and periods of water scarcity.

The MoWR undertakes a wide gamut of activities through various wings that work under the overall aegis of the ministry. These include (1) the Bangladesh Water Development Board (BWDB), which is primarily responsible for the development of major irrigation projects, and implementing various programs, including information management and flood forecasting; (2) the Water Resources Planning Organization (WARPO), which is responsible for nationwide water resources planning and monitoring; and (3) other institutions of the MoWR. Significant among these other institutions are a number of research institutions, such as the River Research Institute (RRI), as well as various coordinating and management bodies, such as the Joint Rivers Commission. The major institutional responsibility for minor irrigation (STWs, DTWs, LLPs, and others), however, lies outside of the MoWR. These aspects of irrigation are under the auspices of the Ministry of Agriculture (MOA) and its various agencies, such as the BADC. Management and operational control of several irrigation schemes has been transferred by the MoWR to the Water Management Group (WMG), which consists of local communities including marginal farmers.

Besides the MoWR, several other ministries have a stake in irrigation and water resources management. The Ministry of Local Government, Rural Development and Cooperatives (MLGRDC) regulates the activities of water management cooperatives. Similarly, the Ministry of Environment (MOE) is involved in the regulation of urban bodies and industries, with the objective of protecting water, especially groundwater, quality (Ahmed et al. 2011). The Ministry of Land (MOL), being the legal owner of surface water resources, is involved in the leasing of land to fishers with revenue as the main objective, but does not regulate the activities of the fishers. It has been observed that this multiplicity of ministries with overlapping stakes in water resources and the lack of clear policy to address issues of minor irrigation management, in addition to overall water resources planning, reflect certain lacunae in the existing water policy and institutional structure (Food and Agriculture Organization 2010b).

## **Challenges**

The impressive growth in irrigation in Bangladesh has not been without its drawbacks. Major fallout of the spread of groundwater irrigation has been the shifting away of land from non-cereal crops such as pulses and oilseeds to mainly rice. This has had adverse effects both on the nutritional content of the diet, with important sources of proteins and other nutrients being in short supply, and on the decline in soil fertility (Hossain 2009). Increase in groundwater withdrawals for irrigation has resulted in declining aquifer levels and has also been detrimental to the supply of drinking water. The environmental impacts of excess groundwater withdrawal pose the most critical challenge to sustainable growth of agriculture in Bangladesh.

There are fears that the fall in the water table level could add to the existing problem of arsenic contamination of groundwater, which has serious health implications. Although the process of high arsenic contamination is not yet clearly understood, groundwater overdraft is believed to be an important factor (Harvey et al. 2002). The rising density of STWs and the associated intensification of crop cultivation have also been linked to declining soil fertility (Alauddin and Quiggin 2008). Also, poor irrigation management, coupled with increased use of agrochemicals, is thought to have had an effect on soil salinity, degradation of fish habitats, and other detrimental impacts on the environment in Bangladesh (Alauddin and Quiggin 2008).

In addition to these environmental costs, the operational costs of sustaining this groundwater economy are also reaching critical levels (Shah et al. 2003). It has been estimated that water use efficiency in STW and DTW command areas is less than 60 percent. This, combined with the fact that around 90 percent of the pumps run on diesel, implies that the cost of pump irrigation is very high and is likely to increase further as fuel costs rise. Already it has not been uncommon to find diesel supply and high price problems during the peak irrigation season. Guaranteeing that the benefits of the spread of irrigation are not lost requires that an adequate supply of diesel at reasonable prices be maintained (Hussain and Iqbal 2011), which is difficult in view of the rising world oil prices. This is a task whose enormity will keep increasing, so securing other sources of power (shifting to electricity) will remain a key challenge.

Considering the environmental and cost concerns of groundwater irrigation, the main challenge in the irrigation sector is to increase surface water irrigation and correspondingly reduce groundwater use, improve water use efficiency, and rehabilitate infrastructure, keeping in view the overall objective of increasing food production (Government of Bangladesh 2011). To increase surface water irrigation, the water distribution system and water management at the farm level has to be improved. This requires (1) investments in developing new distribution channels and rehabilitating and maintaining existing ones; (2) investments in water-saving technologies, such as alternate-wetting-and-drying technology developed by the Bangladesh Rice Research Institute; and (3) strengthening system-level and grassroots-level capacity for managing water resources more efficiently (Ahmed et al. 2011, Government of Bangladesh 2011). Alongside this general thrust to increase surface water irrigation, specific measures are required to improve efficiency of surface water irrigation and saline water intrusion in southern Bangladesh. These include improvements in the field drainage systems, rehabilitation of existing irrigation and drainage systems, flood control measures, capacity development among water users, and improved brackish water management practices.

On the policy front, as mentioned above, Bangladesh is yet to formulate a policy or an act related to irrigation or water management. Except for the Groundwater Management Ordinance, which was in effect from 1985–87 to control the spacing for the installation of tubewells, there has been no specific policy to regulate groundwater usage. Although this was not a problem in the period when the spread of irrigation was still in its nascent stage, the problems being posed by groundwater usage in recent years require that a policy be put in place to manage these challenges. Some steps have been taken in recent years to address these issues in policies, such as the National Agriculture Policy (1999), the National Water Policy (1999), and the National Water Management Plan (2001). These policies have addressed the minor irrigation and water management issues to some extent, but the need for a comprehensive policy, which factors in the emerging challenges of increased irrigation, still exists.

The overlapping mandate of several ministries over water resources has, as noted earlier, not been conducive to optimal water use in the country. Often various government agencies, such as the BWDB and BADC, have functioned at cross-purposes in a climate of competition (Ahmed et al. 2011). Similarly, other ministries with a stake in water resources, such as the MOE and MOL, have been lax in regulating water use by those users under their domain. As a result, water quality in the country has deteriorated even though it is the objective of the MOE, while the fishers who lease land from the MOL have tended to overexploit the water and fish resources due to the short-term lease policy of the MOL. From stakeholder discussions, Ahmed et al. (2011) report that both the MoWR and the MOL have laid more stress on development rather than sustainable use of water resources. Thus, they point out that there is an acute need for raising awareness within the wings of the government itself.

## Farm Mechanization

Use of mechanized means of production in agriculture can be broadly delineated into three categories: (1) farm power and mechanization of farming tasks, (2) irrigation equipment, and (3) postharvest processing equipment. Traditionally, farm power has been derived from human and animal labor, and in Bangladesh, these two sources still form a significant source of power for carrying out farm activities. By 2007, it was estimated that 36.38 million humans and 12.15 million animals formed a part of farm power (Harun-ur-Rashid 2007). In particular, more than 90 percent of the sowing/planting and harvesting of rice in Bangladesh is estimated to be done manually. On the other hand, mechanization has made many inroads in the activities of land preparation, threshing, and milling, as well as in the irrigation sector. The increase in the number of tractors, power tillers, threshers, and shallow tubewells, especially during 1996–2006 (Table 3.8), points to the fact that mechanization is on the rise in Bangladesh’s agriculture.

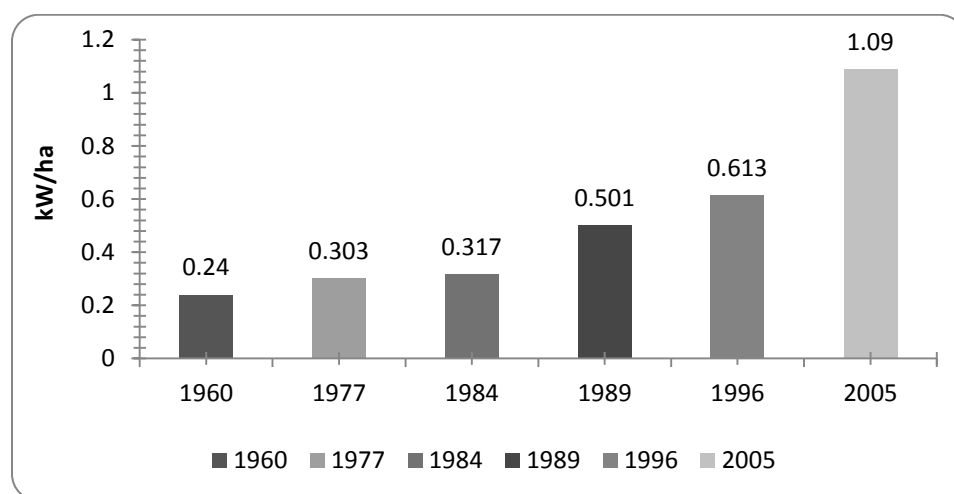
**Table 3.8—Farm power and number of equipment in Bangladesh, various years**

Equipment	1977	1984	1989	1996	2006
Tractor	300	400	1,000	2,000	12,500
Power tiller	200	500	5,000	100,000	300,000
Maize sheller	-	-	-	100	850
Thresher (open drum)	-	500	3,000	10,000	130,000
Thresher (closed drum)	-	100	1,000	5,000	45,000
Deep tubewell	4,461	15,519	22,448	24,506	28,289
Shallow tubewell	3,045	67,103	223,588	325,360	1,182,525
Low-lift pump	28,361	43,651	57,200	41,816	119,135

Source: Islam 2009.

Total farm power availability from all sources (in terms of kW/ha) also shows an increase of more than 77 percent during the period 1996–2005 (Figure 3.7). But this is lower compared to neighboring India, where it was around 1.5 kW/ha in 2007 (Islam 2009), and obviously much less as compared to industrialized economies, such as Japan, Italy, France, and the UK which have farm power availability of 8.75, 3.01, 2.65, and 2.50 kW/ha, respectively (Tandon 2004).

**Figure 3.7—Farm power available (kW/ha), various years**



Source: Islam 2009.

Promotion of irrigation equipment has largely been the focus of farm mechanization policy in Bangladesh. Prior to 1988, in the period when irrigation equipment (and most of other farm equipment as well) was under the public sector control, farm machinery had to be certified by the Agricultural Machinery Standardization Committee of the Ministry of Agriculture. Although this process ensured a measure of quality control, the system was handicapped by the limited number of makes and models that were released in the market. The process of certifying and releasing new and more efficient equipment, which was also in many cases cheaper, was slow and held back the growth of the farm equipment industry. As the government policy in Bangladesh shifted toward reduction of public intervention, the standardization and quality control regulations for farm equipment were done away with (Roy and Singh 2008). Ostensibly, these measures helped speed the proliferation of cheap, affordable machinery, particularly irrigation equipment and power tillers, imported from manufacturing hubs in Southeast Asia. But the lax quality control measures and standardization procedures for farm machinery also led to the spread of substandard and often spurious machinery and spares.

Commentators have pointed to various obstacles to greater adoption and use of mechanized means of agriculture by farmers in Bangladesh. Problems include fragmented lands and small plot sizes, which limit the use of certain machinery; limited capacity for capital investment by the majority of farmers; limited capacity and quality of domestic manufacturing; profusion of substandard imported machines; and lack of a well-developed market for spare parts and maintenance (Islam 2009). Also, agricultural extension and research in Bangladesh has ignored farm mechanization to a large extent, and the need for a comprehensive agricultural technology policy has also been felt (Roy and Singh 2008).

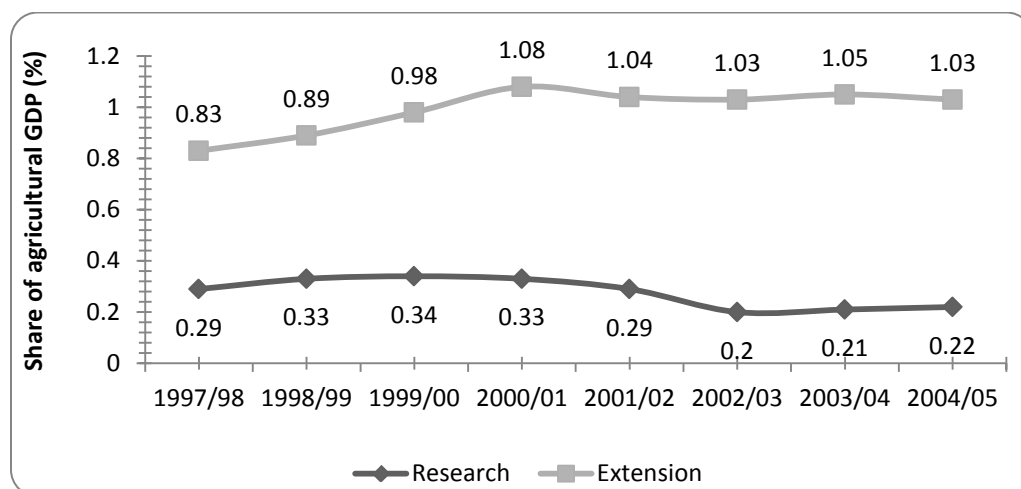
## **Agricultural Support: Research, Extension, and Credit**

### ***Agricultural Research***

Bangladesh's largest gains in agricultural research have mostly been in the rice sector and to some extent other cereal crops. The National Agricultural Research System (NARS) in Bangladesh consists of 10 public research institutes, which are under the purview of the Bangladesh Agricultural Research Council (BARC). These institutes are linked to several ministries, such as the MOA and MOE, have limited autonomy, and are controlled to a large extent by bureaucrats. These institutes have made significant advances toward increasing cereal yields, especially rice, and consequently have contributed to the growth in the agricultural sector. Over time the domestic research institutions have successfully collaborated with the International Rice Research Institute (IRRI) and the International Center for Wheat and Maize Improvement (CIMMYT). The Bangladesh Rice Research Institute (BRRI) has released more than 22 varieties of rice that have proved successful. It has been noted that these varieties continue to be in demand by farmers and are part of the regular seed production program (World Bank 2005). The biggest advances in rice yields have been made through the use of green revolution technologies, which combine improved varieties with the high use of inputs. Later advances owe to the development of *boro* rice varieties, which now provide the bulk of the rice output in the country.

However, in more recent years, the public sector research system in Bangladesh has found it increasingly difficult to generate similar results. A review of the research system observed that the main barriers facing public sector agricultural research in Bangladesh were “inadequate and unstable funding; weak management of the research system, including inefficient allocation and use of available resources, declining quality as well as relevance of research and limited access to new sciences; ineffective institutional arrangements for coordination of research, including weak governance, poor scientific incentives and an eroding human resource base” (World Bank 2005). Public funding for agricultural research has been on the decline, and is currently around 0.2 percent of the agricultural GDP (Figure 3.8), whereas the average across developing countries is around 0.6 percent of agricultural GDP (World Bank 2005, Beintema and Kabir 2006).

**Figure 3.8—Trends in public expenditure for agriculture research and extension, 1997/98 to 2004/05**



Source: World Bank 2005.

The government's country investment plan, 2011, recognizes many of these deficiencies and weakness of the NARS, identifies research priorities of the government and various stakeholders, and provides directions for turning around the public research system to meet the emerging challenges. The areas of research focus identified as priority are (1) developing new varieties for sustainable improvements in the yields of *aus* and *aman* rice<sup>4</sup>; (2) developing technologies and management practices to improve soil fertility, water use efficiency, livestock disease control, and inland and marine aquaculture issues of climate change; (3) managing various other environment-related stresses, such as floods, droughts, water salinity, and brackishness, especially in the coastal regions; (4) and addressing pests and disease control, ecologically sustainable agriculture, and management of biodiversity (Government of Bangladesh 2011). The study by Ahmed et al. (2011) mentioned other high-value crops, such fruits and vegetables that hold great potential for future growth, as meriting research attention. However, these crops do not seem to have found a place in the research priorities listed by the government. Ahmed et al. (2011) pointed out that achieving these research goals will require (1) substantially increasing the quantum of funding available for the NARS institutes; (2) making several institutional changes in the NARS, such as decentralizing research, providing greater autonomy to the research institutes, and reducing bureaucratic control; (3) raising the education standards of agricultural universities to address issues of scientific skill deficiency and brain drain; (4) encouraging private-sector research through partnerships between public and private institutions.

Since the mid-1990s, Bangladesh has gradually eased entry barriers for private-sector research in agriculture. Private-sector research was initially facilitated by the United States Agency for International Development (USAID), and subsequently the World Bank supported the Krishi Gobeshona Foundation, which funds both private and public research. As a result of these efforts, as of 2009, there were some 49 private companies and two NGOs involved in agricultural research (Jaim and Akter 2012). However, not much is known about the research outcomes and costs being carried out by these private players.

<sup>4</sup> Rice is cultivated in three seasons in Bangladesh, *boro* (winter rice), *aus* (summer rice), and *aman* (wet season).

## ***Agricultural Extension***

Agricultural extension in Bangladesh has traditionally been public sector driven, and the major institution of extension activity has been the Department of Agricultural Extension (DAE), functioning under the Ministry of Agriculture (MOA). In the late 1970s and through the 1980s the Training and Visit (T&V) model of extension followed. Faced with issues relating to poor linkages between research and farmers, staff skill levels, and appropriateness of the technologies and information disseminated, the T&V model was replaced with the Farmer Field Schools (FFS) approach, aided by the Food and Agriculture Organization (FAO) and other donor assistance. Under the FFS, the DAE through several thousand extension workers provides comprehensive training on integrated crop management.

In recent years, the extension sector has seen the entry of some new entities. These include a number of nongovernmental organizations as well as some private sector agribusiness enterprises that have started providing extension services to farmers. These extension activities in many cases are a result of contract farming arrangements, particularly in the milk, poultry, seed, oil crops, fruits, and vegetables sectors (World Bank 2005). The major role is still retained by the DAE, as well as some other departments, such as the Department of Fisheries (DOF) and the Directorate of Livestock Services (DLS).

The agricultural extension policy in Bangladesh underwent a major shift with the adoption of the New Agricultural Extension Policy (NAEP) by the MOA. The NAEP envisaged a change in the structure of the extension services from a centralized one to a more decentralized, participatory, and demand-driven service to better serve the needs of farmers. In line with this, the DAE has developed partnerships with several governmental and nongovernmental organizations, covering a wide array of activities suited for farmer needs, such as crop, pest, water, and natural resources management (Jaim and Akter 2012).

Although the new policies represented a significant advance over past practices, the review report cited earlier notes that “many of the changes required under the new policies are still to be fully implemented and internalized” (World Bank 2005, XV). Additionally, the public extension system in Bangladesh is challenged by a skewed budgetary allocation and a lack of effectiveness in spending. As the World Bank report (2005) noted, only about 15 percent of the DAE budget was allocated to operational costs of extension, while the rest was used for payment of salaries for the staff numbering 24,000, of which 16,724 were field staff. In the case of the DLS, the situation was found to be even worse, with almost nil operational funds available. Also, the same report found that limited coverage and reach of extension activity was a barrier. Only about 10 percent of the farmer population had had some direct contact with DAE field staff. The spread has been limited to large farmers, while small farmers and women farmers did not receive the benefits of extension (World Bank 2005).

Besides finances, inadequacies of the human capital with the DAE and institutional weakness in the linkage between extension and other agricultural support services (such as research, agricultural credit, marketing services, and so on) are the other factors limiting the reach of public extension services. Ahmed et al. (2011) mentioned that the DAE itself appears to lack the capacity to learn about new technologies due to the poor quality and inadequate training of its staff. This is in part a reflection of the poor state of agricultural education in the country as a whole. Another reason for this is the weak linkage between research and extension within the public sector.

Recognizing the weak link between research and extension, the National Agricultural Technology Project (NATP) has supported several activities aimed at improving this linkage. Under this, researchers are involved from an early stage in extension planning, and eventually with farmers, through involvement in demonstrations, workshops, and so on. An attempt has also been made to institutionalize the research-extension-farmer linkage through the National Agricultural Technology Coordination Committee (NATCC) at the national level and the Agricultural Technical Committee (ATC) at the regional level. Farmer-to-farmer information exchange is also promoted through Farm Information and Advisory Centers (FIAC) that are being set up across the country (Jaim and Akter 2012). This study also mentioned that these efforts are of very recent vintage and it is too early to evaluate their impacts.

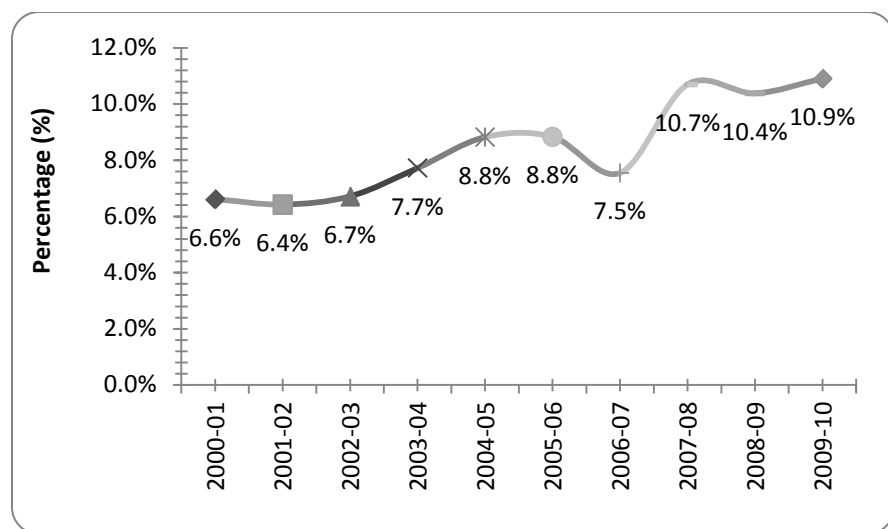
## Agricultural Credit

Securing access to agricultural credit is crucial, especially for a smallholder-dominated agricultural economy, as is the case in Bangladesh. Agricultural credit can be through both formal sources, such as banks, cooperative societies, microfinance organizations, and others, as well as through informal sources, such as moneylenders, credit extended by local input dealers, and friends and relatives in many cases. Although there is scant information on the size and spread of the informal credit market in Bangladesh, informal sources of lending are believed to constitute as important a part of rural credit as formal lending sources, if not more (Ferrari 2008).

The only recent data on agricultural credit comes from a nationally representative survey of 1,838 households carried out by Barkat et al. (2010). The main objective of the survey, however, was to estimate fertilizer use and demand. This survey found that around 38 percent of the farmers sampled availed credit for agricultural activities. The study found that the most common source was loans extended by friends and relatives (30.4 percent). This was followed by credit from NGOs (about 28 percent), Bangladesh Krishi Bank (17 percent), and local moneylenders (6.6 percent). Only 5.6 percent of credit-taking farmers did so from government banks. The study also revealed that with an increase in landholding size, there was in general a greater rate of accessing formal credit sources. It was found that more than half of the landless farmers took agricultural loans from informal sources (56.6 percent), and around 45 percent of marginal and small farmers accessed agricultural credit from informal sectors. On the other hand, around 66 percent of medium farmers and more than 83 percent of large farmers taking credit for agriculture did so from the formal sector.

Following national independence in 1971, rural credit was given a fillip through specialized banks for agricultural credit, such as the Bangladesh Krishi Bank (BKB), and also through the spread of rural bank branches of the nationalized commercial banks (NCBs). In recent years (2000–01 onward), agricultural credit disbursement (in the banking sector) as a percentage of agricultural GDP in Bangladesh has shown some increase, from 6.6 percent in 2000–01 to nearly 11 percent in 2009–10 (Figure 3.9).

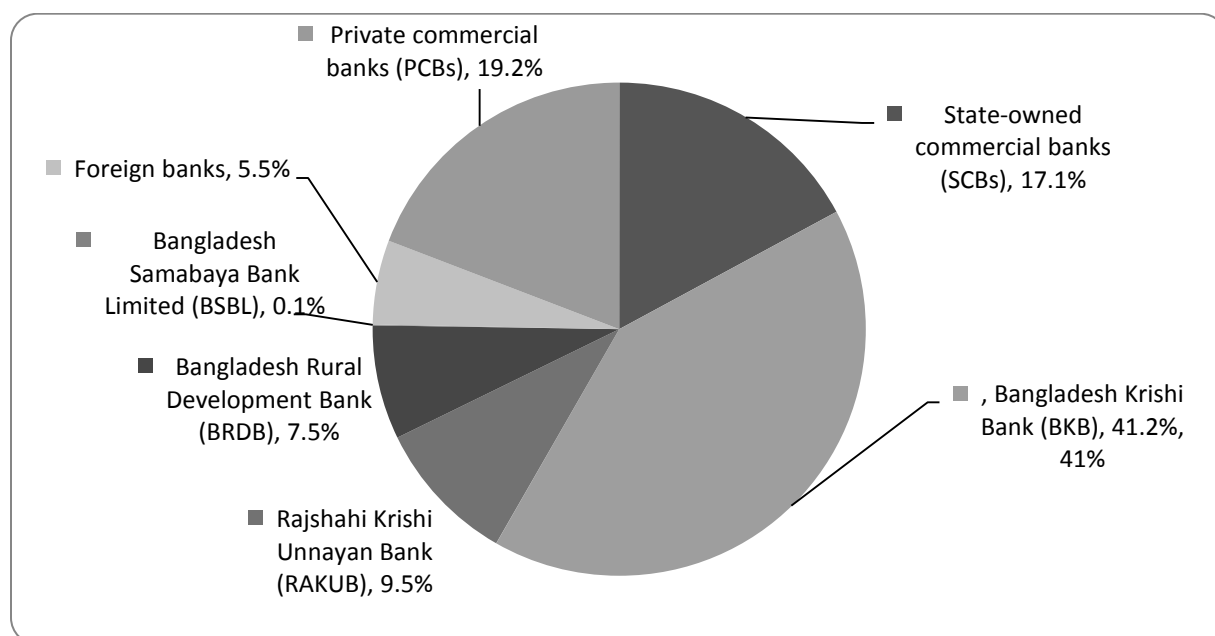
**Figure 3.9—Agricultural credit disbursement as percentage of agricultural GDP**



Source: Authors' estimates based on Ministry of Finance 2010.

The Bangladesh Bank, which is the central banker, issues directives to specialized banks as well as state-owned commercial banks regarding agricultural credit policy. The specialized public sector rural finance banks—the BKB and the Rajshahi Krishi Unnayan Bank (RAKUB)—are the two biggest contributors to agricultural credit disbursement. These two banks have the highest number of rural branches (Hannan undated), and both of these together making up more than 50 percent of the total bank credit to agriculture (Figure 3.10). It has been pointed out in literature on rural finance in Bangladesh, however, that the performance of these two institutions has been poor, with both of them not covering the bottommost classes of rural poor (Ferrari 2008). In recent years there has been an increase in the rural credit portfolio of private and foreign commercial banks in Bangladesh (Bangladesh Bank 2010). Bangladesh has also been the home of microfinance organizations, and many of these institutions extend rural credit through various lending mechanisms. These NGO credit sources have gained a major place in the provision of rural finance and agricultural credit, as evidenced by the results of the study cited above in this section. Some of these organizations, such as the Bangladesh Rural Advancement Committee (BRAC), Association for Social Advancement (ASA), and Grameen Bank, also offer microcredit that targets agricultural credit needs (Alamgir 2009).

**Figure 3.10—Agricultural credit disbursement by category of lender, 2008/09**



Source: Bangladesh Bank 2010.

The major challenge for agricultural credit in Bangladesh still remains one of access and coverage. As mentioned earlier, only 38 percent of farmers reported availing credit for agriculture, with informal sources of credit still being the major supplier of credit for agricultural needs, especially for marginal and landless farmers. Increasing access to banks and other formal sources of credit for all classes of farmers remains a challenge. The study by Barkat et al. (2010) also indicates that the credit needs of farmers are concentrated in particular months, mostly for the *boro* crop. Effective agricultural credit policy will need to factor into this seasonal aspect of credit demand and design agricultural credit agencies accordingly.

## 4. OUTPUT SECTOR

The previous section discussed the policy landscape governing the agricultural input sector and how these influence input use and productivity. Public policy can also be used to intervene on the output side and provide a *pull* for production enhancement. These could be through price supports to make crop production more profitable. They could also be wider policies covering the output sector as a whole and dealing with storage, transport, marketing infrastructure, and other forms of indirect support. In Bangladesh, output policy has largely dealt with the former case, and interventions have been through the public procurement instrument.

Public procurement and distribution policies for foodgrains in Bangladesh trace their origin to the famines that the region experienced in the 1940s. Considering the fallout in terms of human lives lost during this period, government interventions in foodgrain markets were framed to take into account (1) a low production base of rain-fed, fragile mono-crop staples cultivation; (2) fragmented infrastructure, financial, and informational networks; and (c) thin market supplies displaying high prices, large seasonal spreads in prices, and susceptibility to upward spikes at short notice (Chowdhury, Farid, and Roy 2006).

In the ensuing years, the structure of the foodgrain market (revolving primarily around rice) has undergone a number of changes in Bangladesh. The rapid spread of high-yielding *boro* rice, the greater adoption of HYVs by even small farmers, and the improvement in transport and market infrastructure led to rising marketable surpluses, with the majority of farmers becoming net sellers of rice. Chowdhury (1994) reported that in 1989-90 (which was a good harvest year), 70 percent of all farmers were net sellers of rice. The spread of *boro* rice, by adding a new rice harvest season, resulted in seasonal smoothening of prices.

To factor in these changes, the government procurement and pricing policy in Bangladesh has consequently undergone various reforms. The direction of change has broadly been toward reducing the role and size of government interventions and shifting toward greater private sector participation in domestic as well as import markets for foodgrains. Thus, from a largely state-controlled grain market structure that existed at the end of the 1970s, the government role in foodgrain markets in Bangladesh is now limited to procuring enough stocks to meet supply needs for targeted public food distribution interventions and intervening in import markets during times of large shortfall in grains. Table 4.1 traces some of the important landmarks in the changing food policy regime in Bangladesh.

**Table 4.1—Major landmarks in Bangladesh’s food policy regime**

<b>Year</b>	<b>Policy change</b>
<b>1979</b>	A World Bank–produced document, <i>Food Policy Issues</i> (World Bank 1979) laid down the major underlying basis for food policy formulation in Bangladesh. The report backed the existing government policy of optimal national stocks as equal to 1.5 million metric tons (MT) and also suggested security stocks the size of 600,000 MT as “appropriate.”
<b>1981–1982</b>	Under Bangladesh’s Second Five-Year Plan, a long-term plan was promulgated with the objective of accelerating rice production in the country. The Food Policy Monitoring Unit (FPMU) was established to “monitor the food security situation in Bangladesh and implement related policies.”
<b>1986</b>	A study led by Beacon Consultants carried out the first-ever evaluation of the welfare effects of existing channels of food distribution (statutory rationing and modified rationing); the report concluded that both these channels resulted in inequitable operations.
<b>1988</b>	The open market sales (OMS) system stated that “in the event of the market price rising over a meaningful threshold, OMS grains would get disproportionately distributed in poor neighborhoods in order to foster self-selection of the grains being off-loaded.” The government also opened up the irrigation equipment market, leading to a profusion of cheap imports from China and South Korea, which is believed to have led to the growth in irrigated rice production in the country.
<b>1989</b>	The modified rationing (MR) system was replaced by palli rationing (PR). Rice was no longer to be distributed in rural areas, but instead wheat would be distributed. Also, the channel of distribution was through milling units, wherein each licensed mill would receive about 500 kgs of wheat per month; they would then sell the wheat flour to villagers at a preset price. Direct sales of urea by parastatal fertilizer factories to private traders was allowed for the first time, enabling a rapidly increasing number of private traders to move large quantities of urea across the country (Samad et al. 1989). The government started a new procurement program called mill gate purchase (MP). The idea was to procure milled rice from prequalified contractor-mills on a cost-plus basis that pivoted around the “procurement price” (PP) (Chowdhury 1994). Rice procurement rose during 1989/90 to 1991/92 to record levels.
<b>1993</b>	Import of wheat by private mills was legalized. Imports of foundation seed and power-tillers were liberalized. Private wheat imports by licensed large mills and private rice imports were legalized.
<b>1994</b>	The 50-year-old Anti-Hoarding Act, barring merchants from keeping inventories exceeding one week’s worth of working stocks without statutory licenses from the Food Department, was put into abeyance.
<b>1996</b>	Bangladesh implemented the Uruguay Round Agreement on Agriculture.

Source: Chowdhury, Farid, and Roy 2006.

The privatization of rice and wheat imports and the suspension of the Anti-Hoarding Act in 1993–94 marked the end of state control and signaled the start of liberalization of grain markets. It has been argued by researchers that following the liberalization of food policy, the grain markets in Bangladesh have witnessed spatial integration of prices; shortening of grain supply chains, with more farmers selling directly to terminal traders; and favorable supply performance, with rapid expansion in the size of the rice market (Chowdhury, Farid, and Roy 2006). The role of public procurement has generally been on the decline, with a reduction in rice and wheat procurement as a percentage of output (Table 4.2) from 1988–89 to 2007–08, except for some intervening years wherein government procurement went up. Between the mid-1980s and 2006–2008, the share of the public distribution in market foodgrain supply also went down from 13 percent to 4.3 percent (Chowdhury 2010). The government’s share in imports has also declined. Public sector share in total foodgrain imports declined from 100 percent prior to the 1990s to about 25 percent in the early 2000s to just 9 percent in 2007–08 (Chowdhury, Farid, and Roy 2006; Ahmed et al. 2011).

**Table 4.2—Public procurement of rice and wheat in Bangladesh ('000 MT)**

Year	Rice procurement	Wheat procurement	Rice output	Wheat output	Rice procurement as percentage of output	Wheat procurement as percentage of output
1988/89–1989/90	639	47.5	16,700	955.5	3.7	4.95
1990/91–1994/95	461.4	36.4	17,863.8	1,124.2	2.58	3.38
1995/96–1999/00	498.6	171.6	18,843.6	1,674.8	2.62	9.84
2000/01–2003/04	778.5	184.5	21,778.8	1,551	3.75	11.175
2004/05	1,034	1	26,147	976	3.9	0.1
2005/06	1,050	1	26,474	736	3.9	0.1
2006/07	1,139	0	26,139	736	4.3	0
2007/08	869	0	43,504	844	2	0

Source: Chowdhury 2010.

The withdrawal of the public sector from food markets has facilitated several other changes in the system. With the growth in the marketed quantities, there has been an expansion of rural-urban linkages and also linkages between primary product producers and processors in several commodities, including rice. This has had several positive spin-offs for the economy. Rice mills, for example, now account for about 40 percent of the employment in the agroprocessing sector (Ahmed et al. 2011). Further expansion of this sector is likely to bring greater benefits to rural areas, where about 70 percent of the employment in the processing sector is generated. For this to happen, however, continuous investments are needed not only to expand the processing sector but also to improve its efficiency.

Attention should also be paid to the entire value chain, including the structure of trade, transport, and storage. It has been estimated that a reduction of BDT 1 (Bangladeshi taka) per kilogram in the rice marketing margin alone can generate BDT 10 billion of benefits to be shared between farmers and consumers (Ahmed et al. 2011). Past analysis suggests that the improvements in market efficiency following the transition from a public sector-dominated to a private sector-led system have benefited mostly farmers in areas that are well connected in terms of transport links. However, farmers in remote areas that are underserved by transport and communication services have been virtually bypassed. Thus, to ensure that the benefits are more evenly spread, general infrastructure, such as roads and waterways and communication including mobile phones, reach the presently underserved area as well. This in turn requires huge investments, but the need for such investments are not well understood or even debated due to lack of adequate and reliable information on several dimensions of foodgrain markets (Ahmed et al. 2011). Admittedly, these are long-term issues, and investments, when undertaken, would start yielding results only over the long run.

In recent times, some new issues in food markets have cropped up, originating primarily from beyond the borders of Bangladesh but with relevance and repercussions for the country. The spike in food prices in 2007-08 and the subsequent food export bans implemented by grain-exporting countries has forced a rethinking of food policies in Bangladesh, a net food-importing country. In particular, there is a rethinking on the role of public food stock policies as an instrument for stabilizing food availability and prices in the country. Because procurement and maintenance of stocks involve huge costs, the policy options need to be carefully evaluated. A critical question here is the optimal level of stocks that the country needs to carry. This remains an open question in several countries, including Bangladesh. Public stocking would need supporting infrastructure, especially modern storage facilities. Presently, the storage capacity of public warehouses is about 1.7 million tons, which may not be adequate if stocks are to play

an important role in stabilizing prices. Options for involving private warehouses for maintaining buffer stocks need to be explored (Ahmed et al. 2011). But an effective buffer stock policy for price stabilization also requires governmental capacity to monitor and regulate private stocks. Such monitoring capacity, however, is lacking at this time. These are some emerging issues in food markets for which solutions are not obvious. While reassessing and redesigning policies the government should bear in mind the lessons from the past. In particular, excessive intervention in grain markets can be counterproductive in the long run, and open markets and in particular open borders can still play a very useful and positive role. A better approach might be to take a lead in pushing for regional solutions with neighboring countries, especially India, and to urge them to maintain open borders for food.

## 5. CONCLUSIONS

Bangladesh's agriculture has shown impressive growth in recent years, particularly in rice output. A combination of factors seems to have driven these gains: increased access to irrigation; widespread adoption of high-yielding varieties (HYVs); growth in use of inputs such as fertilizers, pesticides, and others; and increased efficiency in the output markets. These drivers of agrarian growth in Bangladesh, in many cases, have received an impetus from government policies. The shift in policy in the input and the output markets led to a transition from a largely public sector-controlled structure to one in which private sector participation gained significance. This shift is visible across all input sectors, such as seed, fertilizer, other chemical inputs, irrigation, and farm equipment, and seems to have had paid dividends in terms of improved availability and affordable access to these inputs by farmers. Without these advances, Bangladesh's foodgrain growth could not have matched up to the population growth and it would not have been able to surmount the food security challenges that it faced in earlier years of its history.

Despite these gains, however, many of the traditional problems continue to plague Bangladesh's agriculture. Landholdings are mostly small and often fragmented, which limits the capacity of farmers to access quality inputs and modern technology. In addition, the input sectors themselves continue to face many of the traditional problems. The seed sector, for example, is dominated by the informal sector, which is outside any legal, regulatory, or quality-monitoring systems. The agricultural research system, dominated by the public sector, continues to face shortages and volatility in its funding, weak management, and ineffective institutional arrangements for undertaking high-quality and relevant research. The public extension system faces similar funding, manpower, and institutional shortcomings. In addition to these sector-specific problems, overall infrastructure bottlenecks in the country, such as with transportation and electricity sectors, also pose problems in accessing inputs and technologies.

Even as these traditional problems continue to affect agriculture, policymakers in Bangladesh are now confronted by numerous new and emerging challenges that may prove to be a threat to the future of agriculture. Some of these challenges are the result of the negative fallout of current agricultural practices and policies, such as excess groundwater withdrawals for irrigation; decline in soil fertility, some of which is as a result of excess and unbalanced use of fertilizers, pesticides, and other agrochemical inputs; and other problems caused by intensive mono-cropping of rice. Past policies that aimed at promoting growth have not paid much attention to regulating input use patterns, resulting in some of these negative consequences.

Other emerging problems have to do with wider changes in the natural environment as well as shifts in world markets and trade, which have consequences for Bangladesh's agricultural sector. For example, recent years have seen periods of supply stress and price spikes, especially in fertilizer markets, resulting from conditions in the world markets, and existing agricultural policies do not seem to offer enough scope for managing such periods of stress.

Bangladesh's agricultural policy also needs to factor in other environmental risks facing the sector. Declining water quality due to arsenic contamination is one such risk, as is the problem of increasing land stress due to urbanization and land degradation. Global climate change also poses a risk for Bangladesh's agriculture, because it could potentially increase the frequency of extreme weather events such as cyclones and floods. Adaptation strategies to cope with these possible impacts and minimizing negative environmental impacts of agriculture would necessarily have to figure prominently into Bangladesh's agricultural policy landscape. The recent move of the government to reduce dependence on hazardous chemical pesticides through promotion of environmentally friendly crop protection practices under the integrated pest management umbrella is a step in the right direction.

The strategy for the future of agriculture in Bangladesh now has to balance the twin challenges of ensuring sufficient growth in output and at the same time promoting judicious use of natural resources to maintain good environmental health. In this regard, the efforts underway through the Cereal Systems Initiative for South Asia (CSISA) closely match Bangladesh's current agricultural priorities. The development of delivery models for the spread of resource conservation technologies (RCTs) for rice and

other cereals holds potential for shifting farmers to a viable and sustainable production system. Developing high-yielding, abiotic stress-tolerant, and disease- and insect-resistant cereal varieties is also crucial for meeting the challenges posed by changing climatic conditions. CSISA's contribution to developing the human resources and capital that can revitalize Bangladesh's agricultural research is likewise important.

On the output side, the country has to reassess its buffer stock policies to address volatility in supply and prices. While doing so, past lessons on the adverse impacts of excessive intervention in food markets should be borne in mind. The country would be better placed to seek regional solutions with its neighbors that seek to ensure open borders for food.

## REFERENCES

- Ahmed, A. U., N. Aberman, M. Jabbar, and N. Akhtar. 2011. Policy Perspectives of the Country Investment Plan for Food and Nutrition Security in Bangladesh. [http://www.feedthefuture.gov/sites/default/files/country/resources/files/PolicyPerspectivesoftheCountryInvestmentPlanforFoodandNutritionSecurityinBangladeshIFPRI\\_March2011.pdf](http://www.feedthefuture.gov/sites/default/files/country/resources/files/PolicyPerspectivesoftheCountryInvestmentPlanforFoodandNutritionSecurityinBangladeshIFPRI_March2011.pdf)) Washington, DC: International Food Policy Research Institute.
- Alamgir, D. A. 2009. "State of Microfinance in Bangladesh." Accessed June 22, 2011. [www.inm.org.bd/saarc/document/Bangladesh.pdf](http://www.inm.org.bd/saarc/document/Bangladesh.pdf).
- Alauddin, M., and J. Quiggin. 2008. "Agricultural Intensification, Irrigation and the Environment in South Asia: Issues and Policy Options." *Ecological Economics* 65 (1): 111–124.
- Ali, M. Y., S. Waddington, D. Hodson, J. Timsina, and J. Dixon. 2008. *Maize-Rice Cropping Systems in Bangladesh: Status and Research Opportunities*. Mexico City: International Center for Wheat and Maize Improvement (CIMMYT).
- Aquastat. 2010. "Aquastat Survey 2010." Accessed June 5, 2011. [www.fao.org/nr/water/aquastat/main/index.stm](http://www.fao.org/nr/water/aquastat/main/index.stm).
- Asaduzzaman, M. 2009. *Getting Agriculture Moving Once Again: Strategic Options for Post-HYV Agriculture in Bangladesh*. London: Department for International Development.
- Asian Development Bank (ADB). 2009. *Key Indicators for Asia and the Pacific*. Manila: Asian Development Bank.
- Bangladesh Agricultural Development Corporation (BADC). 2011. *Annual Report 2008–2009*. Dhaka: BADC Monitoring Division. Accessed March 10, 2011. [www.badc.gov.bd/index.php/publications/annual-report](http://www.badc.gov.bd/index.php/publications/annual-report).
- Bangladesh Bank. 2010. *Bangladesh Bank Annual Report*. Dhaka: Bangladesh Bank.
- Bangladesh Bureau of Statistics (BBS). 2010. "Area, Yield Rates and Productions of Major Crops 2007–2010." Accessed March 7, 2011. [www.bbs.gov.bd/PageWebMenuContent.aspx?MenuKey=166](http://www.bbs.gov.bd/PageWebMenuContent.aspx?MenuKey=166).
- Bangladesh Seed Grower, Dealer and Merchants Association (BSGDMA). 2007. "Bangladesh Seed Industry at a Glance." Accessed March 10, 2011. [www.apsaseed.org/docs/bc3147ea/Bangladesh\\_Seed\\_Industry\\_at\\_a\\_Glance.pdf](http://www.apsaseed.org/docs/bc3147ea/Bangladesh_Seed_Industry_at_a_Glance.pdf).
- Barkat, A., R. Faridi, S. N. Wadood, S. K. Sengupta, and S. N. Hoque. 2010. *A Quantitative Analysis of Fertilizer Demand and Subsidy Policy in Bangladesh*. Dhaka: National Food Policy Capacity Strengthening Programme.
- Beintema, N. M., and W. Kabir. 2006. "Agricultural Science and Technology Indicators (ASTI) Country Brief No. 34." Accessed June 20, 2011. [www.ASTI.cgiar.org](http://www.ASTI.cgiar.org).
- Beacon Consultants. 1986. *The existing system of public foodgrain distribution in Bangladesh and proposals for restructuring. A report prepared for the Ministry of Food, Government of Bangladesh, and funded by United States Agency for International Development (USAID)*. Mimeo.
- Bødker, L., E. Wulff, and J. Torp. 2006. *Seed Sector Country Profile: Bangladesh*. Copenhagen: Danish Seed Health Centre for Developing Countries.
- Chowdhury, N. 1994. *Credit and Bangladesh's Foodgrain Market: New Evidence on Commercialization, Credit Relations and Effects of Credit Access*. Bangladesh Food Policy Project Manuscript No.64. Washington DC: International Food Policy Research Institute.
- Chowdhury, N. 2010. *Price Stabilization, Market Integration and Consumer Welfare in Bangladesh*. Dhaka: National Food Policy Capacity Strengthening Programme.
- Chowdhury, N., N. Farid, and D. Roy. 2006. *Food Policy Liberalization in Bangladesh: How the Government and the Markets Delivered*. MTID Discussion Paper No. 92. Washington, DC: International Food Policy Research Institute.
- del Ninno, C. 2001. *The 1998 Floods in Bangladesh: Disaster Impacts, Household Coping Strategies, and Response*. IFPRI Research Monograph No. 122. Washington, DC: International Food Policy Research Institute.

- Ferrari, A. 2008. *Increasing Access to Rural Finance in Bangladesh: The “Missing Middle.”* Washington DC: World Bank.
- Food and Agriculture Organization. 2010a. FAOSTAT data. Accessed June 29, 2010. <http://faostat.fao.org/site/567/default.aspx#ancor>.
- Food and Agriculture Organization. 2010b. “Country Profile: Bangladesh.” Accessed June 20, 2011. [www.fao.org/nr/water/aquastat/countries\\_regions/bangladesh/index.stm](http://www.fao.org/nr/water/aquastat/countries_regions/bangladesh/index.stm).
- Food Planning and Monitoring Unit (FPMU). 2008. *National Food Balance Sheet*. Dhaka: Government of Bangladesh.
- Government of Bangladesh. 2011. *Bangladesh Country Investment Plan: A Road Map Towards Investment in Agriculture, Food Security and Nutrition*. Dhaka: Government of Bangladesh.
- Hannan, M. (undated). “Rural Credit: An Assessment of Sources & Types Available in Bangladesh.” Accessed June 22, 2011. [www.ruralfinance.org/fileadmin/templates/rflc/documents/1046941038671\\_BOBP\\_IB\\_011\\_\\_1.pdf](http://www.ruralfinance.org/fileadmin/templates/rflc/documents/1046941038671_BOBP_IB_011__1.pdf).
- Harun-ur-Rashid, M. 2007. “Status of Agricultural Engineering Research and Development in Bangladesh.” Accessed June 23, 2011. [www.unapcaem.org/Activities%20Files/A0704/PPT11.pdf](http://www.unapcaem.org/Activities%20Files/A0704/PPT11.pdf).
- Harvey, C. F., C. H. Swartz, A. B. Badruzzaman, N. Keon-Blute, W. Yu, M. A. Ali, et al. 2002. “Arsenic Mobility and Groundwater Extraction in Bangladesh.” *Science* 298 (598): 1602–1606.
- Hossain, M. 2009. *The Impact of Shallow Tubewells and Boro Rice on Food Security in Bangladesh*. IFPRI Discussion Paper No. 00917. Washington, DC: International Food Policy Research Institute.
- Hossain, M., and M. Akash. 1994. *Public Rural Works for Relief and Development*. IFPRI Working Paper on Food Subsidy, No. 7. Washington, DC: International Food Policy Research Institute.
- Hossain, M., and W. M. H. Jaim. 2009. “Diversity, Spatial Distribution and the Process of Adoption of Improved Rice Varieties in Bangladesh.” Paper presented at the international workshop of the International Rice Research Institute, Dhaka, Bangladesh, October 3–4, 2009.
- Hossain, M., A. Janaiah, M. Husain, and F. Naher. 2001. “The Rice Seed Delivery System in Bangladesh: Institutional and Policy Issues.” *Bangladesh Development Studies* XXVIII (4): 1 - 40.
- Husain, A. M., M. Hossain, and A. Janaiah. 2001. *Hybrid Rice Adoption in Bangladesh: A Socioeconomic Assessment of Farmers’ Experiences*. Research Monograph Series No. 18. Dhaka: Bangladesh Agricultural Research Council.
- Hussain, S. G., and A. Iqbal. 2011. *Research Priorities in Bangladesh Agriculture*. Dhaka: Project Implementation Unit (PIU-BARC), Bangladesh Agricultural Research Council.
- IRIN. 2010, January 18. *Bangladesh: Pesticide Poisoning Takes its Toll*. Retrieved July 2, 2011, from <http://www.irinnews.org/Report.aspx?ReportId=87773>.
- Islam, M. 2000. “Consequences of Increased Pesticide Use.” In *Environmental Aspects of Agricultural Development in Bangladesh*, edited by S. Huq, A. Rahman, and G. R. Conway, 117–123. Dhaka: Bangladesh University Press.
- Islam, M. S. 2006. “Use of Bioslurry as Organic Fertilizer in Bangladesh Agriculture.” Paper prepared for presentation at the International Workshop on the Use of Bioslurry Domestic Biogas Programmes, Bangkok, Thailand, September 27–28, 2006.
- Islam, M. S. 2009. “Farm Mechanization for Sustainable Agriculture in Bangladesh: Problems and Prospects.” Paper presented at the 5th APCAEM Technical Committee Meeting and the Expert Group Meeting on Application of Agricultural Machinery for Sustainable Agriculture. United Nations Asian and Pacific Centre for Agricultural Engineering and Machinery, Manila, Philippines. 14 – 16 October, 2009.
- Jaim, W. M. H., and S. Akter. 2012. *Seed, Fertilizer and Innovation in Bangladesh: Industry and Policy Issues for the Future*. Washington, DC: International Food Policy Research Institute.

- Jashim, A., and J. Chowdhury. 2001. "Rice Research in Bangladesh in Retrospect." *Advances in Agronomic Research in Bangladesh* 5: 35–56.
- Katalyst. 2010. "Amendment of Pesticide Rules: A Milestone to Promote Integrated Pest Management (IPM)." Accessed July 2, 2011. [www.katalyst.com.bd/docs/newspieces/News\\_Issue\\_20.pdf](http://www.katalyst.com.bd/docs/newspieces/News_Issue_20.pdf).
- Khondker, B. H., A. R. Bhuyan, H. Khan, and S. Raihan. 2002. *Fertilizer Distribution and Pricing Policy in Bangladesh: Current State of the Art and Overhauling Needed for a Bright Future*. Dhaka: Bangladesh Agricultural Research Council.
- Minhas, B. S., and A. Vaidyanathan. 1965. "Growth of Crop Output in India 1951–54 to 1958–61: An Analysis by Component Elements." *Journal of the Indian Society of Agricultural Statistics* 17 (2): 230–252.
- Ministry of Agriculture. 2007. *Handbook of Agricultural Statistics*. Dhaka: Government of Bangladesh.
- Ministry of Finance. 2009. *Bangladesh Economic Review*. Dhaka: Government of Bangladesh.
- Ministry of Finance. 2010. *Bangladesh Economic Review*. Dhaka: Government of Bangladesh.
- Parveen, S., and N. Nakagoshi. 2001. "An Analysis of Pesticide Use for Rice Pest Management in Bangladesh." *Journal of International Development and Cooperation* 8 (1): 107–126.
- Quader, A. K. M. A. 2009. "Strategy for Developing the Fertilizer Sector in Bangladesh for Sustainable Agriculture." *Chemical Engineering Research Bulletin* 13 (2): 39–46.
- Rahman, M. W., and M. Alam. 1997. "Risk Assessment of Pesticides Used in Bangladesh." *Journal of Civil Engineering* 25 (1): 97–106.
- Rahman, M. W., and L. Parvin. 2009. "Impact of Irrigation on Food Security in Bangladesh for the Past Three Decades." *Journal of Water Resource and Protection* 1(3): 216–225.
- Roy, K. C., and G. Singh. 2008. "Agricultural Mechanization in Bangladesh." *Agricultural Mechanization in Asia, Africa and Latin America* 39 (2): 83–93.
- Samad, A., Haque, A., and Sidhu, S.S., 1989. "Low Cost Intervention Study for the Fertilizer Market of Bangladesh." Dhaka: International Fertilizer Development Center (IFDC).
- Sanzidur, R. 2003. "Farm-Level Pesticide Use in Bangladesh: Determinants and Awareness." *Agriculture, Ecosystems and Environment* 95 (1): 241–252.
- Shah, T., A. D. Roy, A. S. Quereshi, and J. Wang. 2003. "Sustaining Asia's Groundwater Boom: An Overview of Issues and Evidence." *Natural Resources Forum* 27(2): 130–141.
- Talukder, M. M. H. 2011. *Governance Crisis in Production and Distribution of Hybrid Seeds and Its Impact on Market Behaviour and Trust Deficit among Farmers in Bangladesh*. Paper presented at the South Asian Association Regional Cooperation Seed Congress and Fair, Dhaka, Bangladesh, April 10–12, 2011.
- Tandon, S. 2004. *Recent Development of Agricultural Implements and Machinery in India*. Economic and Social Commission for Asia and the Pacific and Asia Pacific Centre for Agricultural Engineering and Machinery Technical Advisory Committee Meeting, Hanoi, Vietnam. 13 – 16 December, 2004.
- World Bank, 1979. *Bangladesh: Food Policy Issues*, Washington, D.C: World Bank.
- World Bank. 2005. *Revitalizing the Agricultural Technology System in Bangladesh*. Bangladesh Development Series Paper No. 7. Washington, DC: The World Bank Office.
- World Bank. 2007. "Bangladesh: Overusing Pesticides in Farming." Accessed July 2, 2011. <http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/SOUTHASIAEXT/0,,contentMDK:21178423~pagePK:2865106~piPK:2865128~theSitePK:223547,00.html>.
- World Bank. 2009. "World Development Indicators." Accessed March 18, 2011. <http://databank.worldbank.org>.
- World Food Programme. 2009. "Agricultural Production & National Food Balance: Bangladesh." Accessed July 15, 2011. [www.foodsecurityatlas.org/bgd/country/availability/agricultural-production](http://www.foodsecurityatlas.org/bgd/country/availability/agricultural-production).







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