Chapter 7

Seeding the Future: Accelerating Seed System Development in Bangladesh

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7.1 Introduction

Evidence accumulated from many developing countries during the past 50 years has demonstrated that yield-enhancing cultivars are vital inputs to sustained agricultural productivity growth, particularly in land-scarce countries where yield growth can only be achieved through intensification (Evenson and Gollin 2003). But sustained productivity growth requires more than just strong scientific expertise and good plant breeding programs. It also requires a modern seed system that has the capacity and infrastructure to multiply, popularize, and distribute these cultivars. And while there are many different designs for a modern seed system, they all share one commonality—they shift seed use practices away from traditional approaches in which farmers select, save, and exchange seeds, to a system that integrates traditional approaches with modern science, public investment, and market signals to provide farmers with more systematic access to improved cultivars and quality seed. Necessarily, this shift also means that seed becomes an economic commodity: it becomes the embodiment of innovative effort undertaken by plant breeders, entrepreneurs, sales representatives, and farmers, across whom the gains from innovation must be distributed in a manner that encourages continuous production and further innovation. It is the role of the policymaker to develop policies that encourage both production and innovation to benefit society.

Seed plays a central role in Bangladesh's development strategy discourse. Since independence in 1971, policymakers have allocated substantial levels of public resources toward plant breeding programs, seed production facilities, and the popularization and distribution of improved cultivars for rice, wheat, and many other crops that are fundamental to the country's food security and economy. Over time, policymakers have also introduced new rules and regulations to shift the seed system from a purely public sector domain to a more complex landscape of public, private, and civil society organizations, and from a purely technology-driven supply system to a more competitive market-based system (Harun-Ar-Rashid, Ali, and Gisselquist 2012; Waddington, Lantican, and Tripp 2012). This combination of public and private investment has contributed significantly to increasing agricultural productivity, particularly with respect to rice (Ahmed 2000; Dorosh 2006; Rashid, Gulati, and Cummings 2008; Hossain 2010). Yet despite Bangladesh's impressive progress, several issues continue to challenge conventional thinking among policymakers, investors, donors, and development practitioners. First, is this new and evolving landscape improving access to improved cultivars for small and marginal farmers? Second, given the continued role of the state in many aspects of the seed system, are there further policy reforms that can encourage sustainable private investment in the development, production, and marketing of improved cultivars without comprising access?

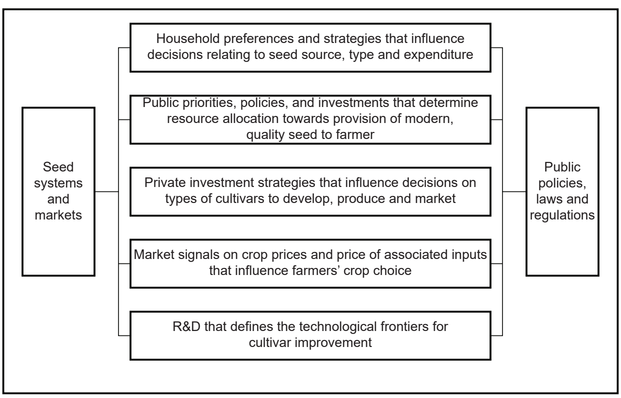
This paper examines the seed system in Bangladesh and the policies that influence its reach and growth. Section 7.2 provides a conceptual discussion to frame the decisions facing farmers, governments, and firms in the seed sector, and to highlight the roles of both crop reproductive biology and public policy. Section 7.3 describes the data and information sources used to analyze the performance of Bangladesh's seed system. Section 7.4 begins with an exploration of the policies, rules, and regulations that have influenced its development, and the impact of these policies on increasing smallholder access to improved cultivars. It then examines the opportunities and tradeoffs between policies designed to simultaneously increase smallholder access to improved cultivars and encourage greater investment in the seed system. Section 7.5 concludes with a discussion of policy options that better delineate appropriate roles for the private and public sectors in Bangladesh's seed system.

7.2 A Conceptual Framework: Towards Better Analysis of Seed Systems

A well-functioning seed system is a balancing act between formal and informal provisioning strategies, market and non-market delivery channels, and public and private sector investment, with the overarching goal of matching the supply of high-quality seed with farmers' demand. To illustrate this balancing act, we present here a conceptual framework that highlights the inherent tradeoffs in a seed system and the policy options for addressing these tradeoffs. We begin with a schematic that lists out the basic elements of a seed system: household decisions, national development priorities, public policies and investment strategies, and private investment incentives, and technological opportunities. We explore each one in detail below (Figure 7.1).

Let us first consider the seed system from the perspective of the ultimate consumer or user—the farmer or farm household. While the rhetoric around seed systems tends to focus on farmers' "inalienable rights to seed" and "seed sovereignty" or on the state's responsibility to supply seed to farmers regardless of cost, we choose to view seed from the farmers' perspective, i.e., as an input to agricultural production. Although farmers face a complex set of decisions when managing a farm, we can narrow their decisions around seed purchasing to just four reasons: (1) to obtain a better cultivar with superior genetic traits; (2) to obtain better quality seed, assuming farmers cannot save seed without incurring significant costs and losses in saved seed viability or quality; (3) to renew the availability of the genetic traits embodied in the cultivar, for example, in the case of hybrids that lose their vigor when second-generation seed are saved and planted; or (4) to obtain seed when their own seed supplies and the supplies from their common sources have been destroyed from some type of disaster.

Figure 7.1: Elements of a Seed System



Source: Authors' perception.

This finite set of reasons helps narrow our understanding of the farmers' decision problem. For example, the farmer might consider a tradeoff between purchasing seed of a newer, improved variety that increases yield or embodies some other desirable trait, versus using tried and tested varieties that she is more familiar with. Or the farmer might consider a tradeoff between whether to use seed she has selected and saved from grain harvested on her farm during the prior season, versus purchasing seeds that is more costly but possibly of a better quality. Or, she might choose to diversify her on-farm varietal portfolio to minimize risks associated with cultivating just one variety, but give up uniformly higher yields in doing so. The choices a farmer makes are often correlated with such individual characteristics as the farmers' experience, education, and access to extension and advisory services; household characteristics such as wealth, landholdings, access to credit for input purchases, and (implicitly) the ability to tolerate risk; and geographic, market, and agro-ecological factors such as land suitability, distance to seed suppliers, and access to irrigation.

Next, let us consider the decision problem facing government—a somewhat different problem than the farmers', but one that is similarly fraught with tradeoffs. The government is responsible for setting national development priorities and, in doing so, building a system that can reliably supply high-quality seed of improved cultivars to farmers so that national goals for agricultural production, food security, and poverty reduction can be simultaneously achieved. The government's approach to building this seed system may take into account competing interests among stakeholders, whether represented directly though democratic institutions or expressed through the voice of civil society, or negotiated across coalitions of interest groups. The contested nature of modern seed systems relates not only to the distribution of the gains to technological innovation, but also to farmers' rights over extant genetic resources, farmers' ownership of the seed as a means of production, intellectual property rights ownership, and concerns related to market efficiency and transparency (see, e.g., Scoones and Thompson 2011; Kloppenburg 1988). Resultant public development strategies, policies, investments, and regulations are all derived from the path chosen by government to negotiate these contested interests and claims.

The more immediate decision problem facing the government is how to optimally invest scarce public resources in a system that must integrate research, production, and distribution of high-quality seed for improved cultivars. The decision cannot be taken on a broad, sector-wide basis because the returns to public investment will vary by crop, agroecology, and market. We illustrate this with several examples, advancing from the simple principles of crop reproductive biology to markets and institutions designed that use biology to incentivize investment in better cultivars.

Consider, for example, rice and wheat. Both are self-pollinating crops, which (in simple terms), means that a farmer can purchase an improved cultivar, plant it, save a portion of the grain from harvest, and replant the grain as seed in the subsequent year *without experiencing significant loss* of the variety's desirable genetic characteristics such as yield, resistance to pests and diseases, or tolerance to abiotic stresses. During the past five decades, this mechanism—the combination of farmers' traditional seed-saving practices and public investment in breeding, production and distribution—has been the primary channel for supplying smallholders with new seed-based technologies for rice and wheat. And through this mechanism, the largest portion of the gains from innovation is appropriated by the farmer, and only nominal remuneration is provided to the innovators who developed and distributed the cultivar. But if the innovator is a public sector organization fulfilling its mandate to increase agricultural productivity, then the distribution of these gains is immaterial, and the costs of research, development, and delivery can be recouped from public funding. In effect, society places a value on public investment in this mechanism and is willing to finance it because the social gains are desirable.

The downside, however, is that the combination of farmer seed-saving practices and public investment provides minimal incentive to private sector agents to invest in breeding, production, and distribution. This is a classic market failure: the social benefits of making improved cultivars available to farmers exceed the private benefits of doing so. This market failure is the basic rationale for public investment in cultivar improvement and seed provision, and it extends from rice and wheat to other self-pollinating and asexually propagated crops such as legumes, pulses, potato, sweet potato, and cassava.

That said, market failures in seed systems can be overcome through two channels: biology and policy. First, consider we consider the reproductive biology of maize, specifically hybrid maize which represents the lion's share of all maize cultivated globally and which differs significantly from the rice, wheat and the other crops described earlier. Hybrid crops exhibit the unique characteristic of heterosis, or an increase in yield or vigor that results from genetic contributions derived by crossing distinct parental lines. However, since yield gains from heterosis decline dramatically after the first generation of seed is cultivated, farmers are compelled to purchase new seed each season, thus creating economic value. Innovators can appropriate the gains from innovation and recoup their investments in research. Thus, the research, development, production, and marketing of hybrid maize is largely a private sector venture throughout the world. The economic incentive attributable to crop reproductive biology extends to other crops that have been hybridized, including sorghum, pearl millet, pigeon pea, and rice.

Second, market failures can be overcome through policies, specifically, legal mechanisms that allow private innovators to appropriate the gains from innovation. Institutions such as intellectual property rights (IPRs) allow companies to charge remunerative prices for seed, reward innovators for their successful investments in cultivar improvements, and reduce the transaction costs associated with contested claims over the rights to innovation rents. However, IPRs can also be costly to enforce and may constrain market reach to only those who are economically, geographically, or otherwise inclined to purchase seed at market prices.

Despite this seemingly neat division between the spheres of (publicly resourced) self-pollinating/asexually propagated crops and (privately resourced) hybrid crops, and despite the convenient biological and policy solutions available to overcome market failures, the reality of a modern seed system is much more complicated. For example, many governments in industrialized and developing countries invest in breeding programs for a wide range of crops—self-pollinating, asexually propagating, and hybrids—as part of their commitment to basic, upstream research where only the government can absorb the costs and risks associated long time horizons and uncertain outcomes. These investments are often essential to creating the basis for subsequent commercialization of viable technologies by the private sector. In other cases, governments invest in breeding programs and seed production activities because farmers may be constrained in their ability to purchase improved cultivars at a remunerative market price due to limits on farmers' purchasing power, geographic constraints to market access, or simply because the crop is question is used solely for own-consumption and does not generate sufficient income for farmers to purchase seed.

Yet, despite solid reasons for government involvement in the seed market, there are also tradeoffs to such involvement, especially in the medium- to long-term. Public breeding programs can crowd out private investment in cultivar improvement, while seed regulations meant to protect farmers from predatory marketing practices can also inhibit private investment and innovation. Seed production by parastatal can weigh heavily on government budgets and allocate scarce government funds away from other important public investments such as agricultural research, rural infrastructure, or social welfare improvement. For governments, this is the fundamental tradeoff between direct state intervention in seed production and distribution, and indirect intervention through policies and regulations designed to encourage private investment (see, Naseem, Spielman, and Omamo 2010).

Next, we turn to the firm's decision problem, which should be fairly obvious by now. The firm must decide how to invest in remunerative activities in the seed system, specifically, how to appropriate the gains from innovation. The firm may choose an appropriation mechanism, for example, developing and marketing hybrids or seeking IPR protection for its non-hybrid products. The firm may also choose to specialize in a specific part of the seed system, for example, in developing and licensing out high-quality breeding materials, or by purchasing breeding material from public and private sources and multiplying large seed quantities for sale to farmers. Still other firms may choose to integrate their activities in end-to-end business models that cover advanced breeding and retailing. Whatever the choice of activities, the decision problem facing the firm is how to maximize the firms' profits given the costs of inputs required to develop, produce and market seed.

Ultimately, seed provisioning strategies rely on close integration between the public and private sectors. The question is whether the institutional architecture in a given country is efficient, effective, and open enough to encourage diverse provisioning strategies that are responsive to the heterogeneity across crops, geographies, and households. This is important given the expectations placed on the agricultural sector to improve food security, reduce poverty, and conserve the environment under ever-greater economic, demographic and climatic stresses. Towards that end, an analysis of a country's seed system requires in-depth understanding about the country's public research system, its regulatory system and the costs of regulation, its seed supply system, and the adequacy of information available to a heterogeneous farming population. We examine these aspects in the context of Bangladesh in the next section.

7.3 Data and Data Sources

Our analysis of the performance of Bangladesh's seed system draws on data and information from several sources. First, we draw on information extracted from two studies on the country's seed system that were commissioned by the International Food Policy Research Institute (IFPRI) in 2013. These studies were done by the Bangladesh Institute of Development Studies (BIDS) (Ali and Basher 2013), an autonomous public multi-disciplinary organization, and the Center for Agri-research and Sustainable Environment and Entrepreneurship (CASEED 2013), a private research and consulting firm. They reviewed the existing policies, regulations and acts pertaining to seed and also identified the gaps and constraints in the various policy provisions as well as their implementation. Information from these studies are augmented with several recent studies covering specific aspects of Bangladesh's seed system that will be referred to in subsequent sections.

Second, we draw on official figures on seed system performance generated by various government entities: (i) the Seed Certification Agency (SCA), which regularly provides data on varietal registration of different crops; (ii) the Seed Wing of the Ministry of Agriculture which regularly publishes data on seed demand and supply in Bangladesh; and iii) the Bangladesh Agricultural Development Corporation (BADC), the state-owned enterprise mandated to produce and distribute improved cultivars in Bangladesh.

Third, we examine data from two recent household studies. The first survey is the Bangladesh Integrated Household Survey (BIHS), a nationally representative survey, covering 5,500 rural households across Bangladesh that was designed by IFPRI in 2011-2012. See Ahmed (2013) for complete details of the survey aims, its sampling frame, and the questionnaire design. The second survey is a 2013 agricultural technology adoption survey also designed by IFPRI to collect information on the uptake of stress-tolerant varieties of rice by farmers in the southern region of Bangladesh.[1]

7.4 Seed System in Bangladesh

7.4.1 Policies, Regulations, and Processes

Bangladesh's farmers have long relied on their own efforts to select, save, and exchange seed with desirable genetic characteristics. Even today, these informal seed systems are an important source of seed for rice and many other crops. These informal systems are also closely intertwined with the country's formal seed system that was established in the 1950s. In its initial phases of development, this formal system combined public investments in plant breeding through the national agricultural research system (NARS) and public universities, with seed production, promotion and distribution through the Bangladesh Agricultural Development Corporation (BADC), and the Department of Agriculture Extension (DAE) (Figure 7.2). The hallmark of this system was the introduction of high-yielding, short-stature *boro* rice cultivars that put Bangladesh on the path to surplus rice production in the 1980s (Hossain 2010).

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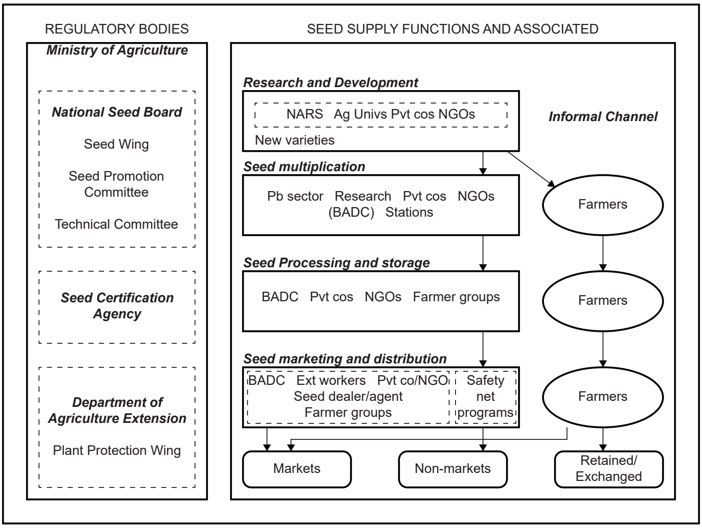
[1] The survey collected information from 3,400 randomly sampled rice farmers. It is representative of the Feed the Future (FtF) zone which covers most of southern Bangladesh and parts of Dhaka division. FtF is the US government's global hunger and food security initiative to support country-driven approaches to tackling hunger and poverty.

Figure 7.2: Seed System in Bangladesh: Functions, Actors and Regulatory Bodies



BADC Bangladesh Agricultural Development Council
cos. Companies
NARS National Agricultural Research System
NGO Non-governmental organization
Pvt. Private

Source: Authors' perception.

In the late 1980s, the Government of Bangladesh introduced several policy reforms designed to liberalize the agricultural sector in line with recommendations of the structural adjustment programs of the World Bank and IMF. For the seed system, the highlight of these reforms was the 1993 National Seed Policy, which called for balanced development of the seed sector by providing equitable opportunities to the public and private sector at all stages of the seed industry from breeding to marketing of seeds. The policy aims to change the BADC's role in Bangladesh's seed market by (i) limiting BADC seed production to notified[2] crops only, (ii) calling for the gradual withdraw of BADC from seed production of seeds of all

[2] Five crops *viz.* rice, wheat, potato, sugarcane and jute have been deemed as "notified" crops, requiring that the government test the cultivars for value in cultivation and use (VCU) and distinctiveness, uniformity and stability (DUS) prior to their approval for commercial introduction. For the non-notified crops, registration involves only an application and testing requirements are mandatory only for breeder and foundation seed.

other crops, (iii) requiring BADC seed prices to better reflect its costs, and (iv) phasing out subsidies to BADC. This policy was followed by the Seed Rules, 1998, wherein the mandatory requirements for seed certification was relaxed, thereby allowing seed producers to market truthfully labeled seeds.

Despite these policy reforms, the tangle of rules and regulations is still cited as one of the most significant barriers to growth and investment in Bangladesh's seed system (Hossain et al. 2001; Harun-Ar-Rashid, Ali, and Gisselquist 2012; Waddington, Lantican, and Tripp 2012). The time, effort, complexity, and costs required to register and release a new variety are considered onerous by both public and private innovators. Furthermore, new restrictions set forth under the 2005 amendment to the Seeds Act saw a reversal of several provisions in the 1993 policy, and prohibited private firms from conducting breeding activities for any notified crops, with the exception of breeding related to hybrid rice. To better understand the complexity and restrictions in this system—as well as some of the opportunities that have emerged from the original reform efforts of the 1990s—we examine the current process required to release new varieties and hybrids in Bangladesh.

For inbred varieties of notified crops, it is the responsibility of breeders from public research organizations to submit an application for new variety registration to the National Seed Board (NSB). The NSB lies under the control of the Ministry of Agriculture and is responsible for advising government and implementing seed policies and regulations covering varietal registration, seed quality, and other related aspects. For variety approval and release, new varieties have to undergo two types of variety tests (i) test for value, cultivation and use (VCU) and (ii) test for distinctness, uniformity and stability (DUS). Although the SCA is responsible for carrying out both VCU test and the DUS test, in reality only the DUS test is done by the SCA. The VCU test is done by the breeder himself through multi-locational trials that are conducted over two years and in six locations under the direction of field teams headed by the Department of Agriculture Extension (CASEED 2013).

Once it is confirmed that the variety being tested is not a duplication of some other existing variety, field reports are tabulated by the SCA and sent to the Technical Committee (TC) of the NSB. The TC which is headed by the Executive Chairman of the Bangladesh Agricultural Research Council (BARC) submits a recommendation to the NSB for release of the variety.

For non-notified crops, the process is slightly simpler. Commercialization and release only involve a straightforward application to the Seed Wing of the NSB with select details on the distinguishing characteristics of the variety, ecological and cultural requirements, and susceptibility to diseases and pests. The absence of cumbersome procedures for varietal registration of these crops seems to generally reflect a belief in the regulatory system that non-notified crops are not important enough to register. This means that the regulatory costs associated with breeding, producing, and marketing non-notified crops are relatively lower than the costs for notified crops, thus opening the door to private investment (Table 7.1). Only in instances where seed for non-notified crops is imported, is there an additional layer of regulatory scrutiny. Specifically, phyto-sanitary safety of imported seed (typically, vegetable and hybrid rice seed) are examined by the Plant Protection Wing of the Department of Agriculture Extension which acts as the National Plant Quarantine Authority that was sanctioned under the Plant Quarantine Act of 2011.

Table 7.1: Registered Cultivars introduced by Public and Private Agencies, 1971-present

Crop	Public Agencies		Private Agencies	
	Pre-liberalization (1971-93)	Post-liberalization (1994-2012)*	Pre-liberalization (1971-93)	Post-liberalization (1994-2012)*
Notified crops				
Rice:				
Modern variety	29	40	-	3
Hybrid	0	3	-	89
Wheat	18	9	-	0
Potato	12	27	-	0
Sugarcane	10	14	-	0
Jute	8	8	-	0
Non-notified crops				
Maize	5	19	-	98
Vegetables	116	116	-	1064
Pulses	9	50	-	4

*For maize, vegetables and pulses, figures are till 2011.

Source: Authors' compilation based on SCA's list of approved varieties available at http://www.sca.gov.bd/.

It is worth pointing out while the regulatory bodies responsible for varietal evaluation and registration are mandated to involve representatives of the public, private, and civil society sectors in their composition and decision-making, the current membership is drawn primarily from the public sector (Table 7.2).

Table 7.2: Representation of the Private Sector in Regulatory Bodies

Regulatory authority	Total members	Number of members		
		Public sector	Private sector	Farmers' groups
National Seed Board (NSB)	20	17	2	1
Technical Committee of the NSB	16	14	1	1
Seed Promotion Committee of the NSB	18	17	1	0

Source: Adapted from CASEED (2013).

Once a variety is released in Bangladesh, the next regulatory hurdle is seed quality assurance. Two separate systems operate at present—seed certification and truthful labeling—and are applied for different crops at different points in the production system. For notified crops produced by public agencies, seed certification is compulsory for breeder seed (BS) and foundation seed (FS), as per the 1998 Seed Rules. For seed of both notified and non-notified crops that is sold to farmers directly, seed must only be truthfully labeled. Since the policy was relaxed to allow for truthfully labeled seed (TLS), approximately 80 percent of seed supplied to the farmers is truthfully labeled, including seed that originates from BADC, the private sector, and NGOs (CASSED 2013). For imported seed, the Plant Protection Wing (under the Department of Agriculture Extension) serves as the national plant quarantine authority and issues a phyto-sanitary certificate for imported seed. The law requires importers to bring in only certified seeds, and once the certificate has been issued, then the seed can be sold to farmers.

Several seed producers also maintain their own, in-house quality assurance systems. For example, BADC has its own quality control department, while some private firms and NGOs manage their own quality assurance systems to ensure that their seed meets farmers' expectations for purity, germination, and expression of the genetic traits embodied in the variety or hybrid (Bødker, Wulff, and Torp 2006; Waddington, Lantican, and Tripp 2012). While TLS and self-regulation reduce the regulatory costs of releasing improved cultivars and hybrids into the market, they do pose their own set of problems. Specifically, firms (whether public or private) may not have the incentive to ensure seed quality if farmers do not seek recourse through the judicial system or if the judicial system has insufficient capacity to adjudicate on fraudulent seed sales. An alternative approach to quality assurance, such as monitoring the open market for fraudulent or poor-quality seed through the SCA, is limited by insufficient field staff—only 30 seed inspectors for the entire country—and by insufficient seed testing facilities and related resources (Hossain et al., 2001).

Ultimately, seed is distributed in Bangladesh through three main channels. First, BADC sells the seed through its own network comprising of with 22 regional offices, 42 district sales centers, and 36 *thana* sales outlets (BADC 2013). Second, BADC distributes seed through a separate network of more than 300 companies, merchants and traders, 16,000 registered seed dealers, and as many as 120,000 seed retailers all over the country (CASEED 2013). BADC seed is sold at cost, and the parastatal's financial viability is implicitly aided by a subsidy that comes from public funding of its recurrent costs. Third, the private sector—a mix of small farmer seed entrepreneurs, one-man owned wholesalers/importers, international seed companies and joint venture companies—sells seed through private seed dealers and middlemen (Bødker, Wulff, and Torp 2006). Fourth, NGOs distribute seed through community groups and other civil society channels. It is worth noting that NGO participation in the seed system is non-trivial: BRAC, Bangladesh's largest NGO, has a seed distribution channel that includes around 550 dealers and distributors, and over 4,000 retailers (BRAC 2013). Seed distribution efforts receive support from the national Agriculture Extension Policy which was subsequently revised under the New Agricultural Extension Policy (NAEP) in 1996. The NAEP introduced a major shift in the provision of public extension by requiring the DAE to evolve from a centralized extension service provider to a more decentralized and pluralistic system (World Bank 2005). The provision of information on new varieties is part and parcel of this system's mandate.

7.4.2 Seed System Performance

One way of assessing seed system performance is to simply categorize Bangladesh in terms of its stage of seed system development. Pray and Ramaswami (1991) describe four stages. In the first stage, farmers rely on traditional practices of seed saving, selection, and exchange. In the second stage, farmers begin cultivating improved (modern) varieties that are bred by NARS or imported from foreign sources, and produced by parastatal or commercial seed companies. In the third stage, farmers cultivate modern varieties widely and the private sector becomes a significant source of innovation in breeding, production, and marketing, eventually becoming the primary source of improved varieties and hybrids in the fourth stage.

At present, Bangladesh may be categorized as being in the late phase of the second stage, but is rapidly evolving toward the third stage. Most seed is still produced by farmers themselves and breeding, production, and distribution are still the primary domain of the public sector. However, the growth of private and NGO investment in breeding (e.g., BRAC's investments in hybrid rice) and marketing suggest signs for a significant transition (Harun-ar-Rashid, Ali, and Gisselquist 2012; Spielman et al. 2012).

To provide a better sense of seed system performance in Bangladesh, we look at several indicators. We examine below the national trends in seed multiplication and seed distribution. From the farmers' point of view, we explore their seed purchasing decisions and adoption rates across a range of crops, varieties, and divisions. We then calculate the average varietal age of specific popular rice varieties is also calculated.

7.4.3 Seed Multiplication and Distribution

Bangladesh's modern seed system has been fairly productive with respect to releasing new varieties of key food staple crops, particularly from the public sector side. Since 1970, the Bangladesh Rice Research Institute (BRRI) has released 65 modern rice varieties (61 inbreds and 4 hybrids), with an additional 10 varieties released by the Bangladesh Institute for Nuclear Agriculture (BINA) (as per the BRRI and SCA websites). Releases of improved wheat and potato have also come from the Bangladesh Agricultural Research Institute (BARI) while the Bangladesh Jute Research Institute (BJRI) and Bangladesh Sugarcrop Research Institute (BSRI) have released improved cultivars for their mandated crops (see Table 7.1). In most cases, these public sector efforts have been aided by collaborations with the Consultative Group for International Agricultural Research (CGIAR) centers, and with support from multilateral and bilateral donor funding.

The public sector has also been fairly effective at supplying seed—foundation seed for use in seed production and certified or truthfully labeled seed for sale to farmers—through the BADC (Table 7.3). Between 2003/04 and 2013/14, foundation seed production for vegetables and pulses—both non-notified crops—grew at an annual rate of 15 and 21 percent, respectively (Table 7.5). The BADC's distribution infrastructure is aided by both DAE and the private sector (Table 7.4).

Table 7.3: Quantity of Foundation, Certified and TFL Seed of Select Non-Notified Crops produced by BADC since 2003-2004

Year	Foundation Seed				Certified and TFL seed			
	Maize	Pulses	Oilseeds	Vegetables	Maize	Pulses	Oilseeds	Vegetables
	(metric tons)							
2003-04	4.0	35.7	36.4	10.9	-	261.9	408.0	13.0
2005-06	12.5	89.2	101.7	11.0	-	314.0	416.0	42.9
2009-10	15.1	129.9	140.3	23.0	115.8	1078.1	871.7	67.6
2012-13	32.9	299.8	149.8	30.7	223.1	1736.2	1429.0	90.5

Source: Authors' calculations based on BADC annual report (various years).

Table 7.4: Proportion of Commercial Seed distributed by BADC, DAE and Private Sector

	2008-09			2009-10			2010-11			2011-12		
	BADC	DAE	Private	BADC	DAE	Private	BADC	DAE	Private	BADC	DAE	Private
	(percentage)											
Aus	45	55	0	35	65	0	22	78	0	31	69	0
Aman	43	57	0	36	54	10	39	51	10	45	46	9
Boro	40	37	24	49	34	17	53	30	16	52	27	21
Wheat	64	36	0	69	31	0	69	31	0	69	31	0
Maize	2	0	98	1	0	99	2	0	98	6	0	94
Pulses	96	4	0	34	66	0	48	52	0	39	61	0
Potato	28	0	72	27	0	73	31	0	69	41	0	59
Vegetables	7	0	93	10	0	90	12	0	88	11	0	89

Source: Authors' compilation based on database of the Seed Wing, Ministry of Agriculture.

Although the Ministry of Agriculture reports a gap between seed demand and supply (Table 7.5), it should be recognized that "seed requirement" figures are heuristic at best and take insufficient account of price determinants of demand—of the seed itself, of the crop for which demand is derived, and of the price of complements (e.g., synthetic fertilizer) and substitutes (e.g., saved seed)—as well as non-price determinants such as genetic traits, seed quality, timeliness of delivery, and accessibility.

Table 7.5: Seed Requirement and Commercial Seed Distribution for Select Crops, 2008-09 to 2011-12

Crop	2008-09		2009-10		2010-11		2011-12	
	Seed req	Seed dist	Seed req	Seed dist	Seed req	Seed dist	Seed req	Seed dist
	('000' m tons)							
Boro	100.55	91.89	99.50	90.41	113.92	108.84	130.75	124.24
Aman	168.00	39.48	167.88	48.81	156.59	51.73	154.25	58.00
Aus	37.00	1.91	36.50	2.21	31.38	4.31	34.50	5.58
Wheat	70.20	31.17	69.60	34.16	45.00	39.34	55.70	39.84
Maize	5.78	4.58	6.80	4.04	4.56	4.59	5.00	4.80
Pulses	20.97	0.88	20.97	1.95	22.21	2.51	23.20	2.74
Potato	410	48.20	410	52.30	477	59.45	600	47.82
Vegetables	2.62	1.09	2.62	0.84	4.10	0.85	4.50	0.89

Note: The term "seed" here denotes both regular seed and non-seed planting material such as cuttings, buddings, saplings, and other planting materials. "Seed req" denotes seed requirement, and "seed dist" denotes "seed distributed."

Source: Seed Wing, Bangladesh Ministry of Agriculture, various years.

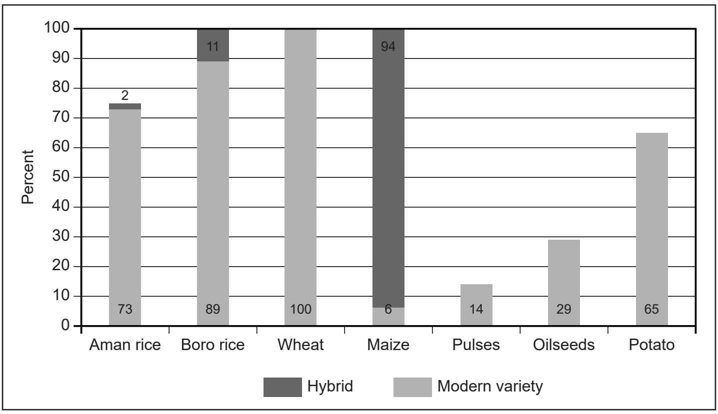
Despite the limitations of official demand assessment calculations, the figures in Table 7.4 do provide a snapshot of the private sector's role in seed provisioning. The private sector dominates the market for maize and vegetable seed and, to a lesser extent, potato. The private sector also plays an increasing role in the market for hybrid rice, where a total of 76 rice hybrids have been introduced by private companies since 2000 as compared to five hybrids originating from BRRI (Harun-Ar-Rashid, Ali, and Gisselquist 2012; Spielman et al. 2012). It is worth noting here that the term "private companies" used above also includes NGOs—specifically BRAC, the current market leader in hybrid rice.[3] It is also worth noting that while private (for-profit) companies and (non-profit) NGOs such as BRAC have forayed into the seed market following policy reforms in the 1990s, their investments have often also been supported by donor projects designed to encourage private investment in agricultural input markets (see Harun-Ar-Rashid, Ali, and Gisselquist 2012).

[3] In the latter half of 2000s, BRAC began investing in agricultural research and has since released 9 vegetable varieties, three maize hybrids, and three rice hybrids from its own research facilities (BRAC 2012). In 2009 the agency invested 141.6 million taka accounting for 5 percent of the country's total agricultural R&D spending (IFPRI 2011). As of 2011, BRAC accounted for an estimated 32 percent of the hybrid rice seed market and 50 percent of the maize seed market in Bangladesh (BRAC 2013).

7.4.4 Farmers' Technology Uptake for Rice and Average Varietal Age

Another useful performance indicator is the extent of adoption of improved cultivars by farmers (Figure 7.3). Data from BIHS indicate that the share of farmers growing modern rice varieties during the *aman* (monsoon) season totals 73 percent, with an additional two percent of farmers cultivating hybrids during the season and the remainder cultivating traditional varieties. The irrigated *boro* rice season—a rotation only feasible with the combination of tube well irrigation and short-stature, short-duration modern varieties—the share of farmers cultivating modern varieties unsurprisingly increases to 89 percent, with the remaining 11 percent cultivating hybrids. For other crops, comparable shares of farmers cultivate modern varieties or hybrids: 100 percent in the case of wheat and 94 percent in the case of hybrid maize.

Figure 7.3: Share of Farmers Cultivating Modern Varieties, 2011-12



Source: Authors, based on data from Ahmed (2013).

Improved cultivar adoption is much lower for non-cereal crops such as pulses, oilseeds and potatoes. In fact, pulses and, to a lesser extent, oilseeds are predominantly local varieties. This is not surprising given the NARS relatively limited performance around non-cereal crop improvement. BARI released its first improved lentil variety in 1991 and its first varietal release of grass pea in 1995. Altogether, the NARS has only released seven varieties of lentils (*masur*) and three varieties of grasspea (*khesari*) to date. Improved cultivar adoption for potatoes has been somewhat better with 65 percent of the farmers growing modern varieties, a likely reflection of the fact that BARI has released nearly 50 varieties since independence.

But crop-level aggregations of national data reveal only a limited amount of information. More disaggregated, variety-specific data provide insight into the prevalence of modern varieties, and the extent to which older modern varieties have been replaced by newer modern varieties with higher yields, more effective biotic and abiotic stress tolerance, or other desirable traits. For instance, wheat cultivation in Bangladesh is concentrated around two relatively older wheat varieties—*Sonalika* and *Kachan*—released in 1974 and 1983 respectively (Waddington, Lantican, and Tripp 2012). Few farmers have adopted more recent wheat variety releases such as *Shatabdi* (2000) and *Prodip* (2005) that were bred to address stress susceptibilities identified in the older wheat varieties. While the persistent use of older modern varieties by farmers may be partly attributable to farmer and consumer preferences for certain characteristics associated with these varieties, it may also be an issue of insufficient production, marketing and distribution.

The reliance on older modern varieties is also found in rice, particularly in *boro* rice. Just two varieties—BR 28 and BR 29, both released in 1994—account for cultivation by more than 50 percent of the rice farmers and occupy close to 70 percent of the country's acreage under boro rice. Across all rice growing seasons in Bangladesh, just five varieties account for 53 percent of rice cultivated area (Table 7.6). The average age of these varieties (weighted by cultivated area) is 20 years, suggesting a strong reliance on older modern varieties and relatively slow varietal turnover.[4] These observations are constant across all farm sizes.

Table 7.6: Rice Cultivated Area by Variety and Average Variety Age in Bangladesh

Farm size	Share of all rice cultivated area planted to top 5 varieties					Average age of top 5 varieties (Years)
	BR 29[a] (1994)	BR 28[a] (1994)	BR 11[c] (1980)	Hira[b] (2008)	BR 22[c] (1988)	
Marginal farmer (<.5 acre) (n=993)	17.88	21.57	10.46	1.23	3.55	20.75
Small farmer (.5-1.49 acres) (n=1,269)	18.88	20.70	10.35	2.76	3.18	20.24
Medium farmer (1.5-2.49 acres) (n=347)	18.86	17.33	11.00	3.30	2.06	20.29
Large farmer (2.5 acres and above) (n=2,830)	19.88	15.44	8.55	4.81	1.26	19.20
Overall	19.08	18.43	9.97	3.36	2.38	20.01

[a] denotes *boro* variety; [b] denotes *boro* hybrid; [c] denotes *aman* variety.

Note: Year of release for a specific variety is denoted above as "(yyyy)." The "average age of top 5 varieties" is calculated here as the average age of the top 5 varieties weighted by the share of area planted to each top-5 variety from the total area planted to all top-5 varieties.

Source: Authors, based on data from Ahmed (2013) and BRRI (http://tinyurl.com/oywzg3u).

[4] The average variety age for rice weighted by area under cultivation has been calculated along the lines of Brennan and Byerlee, 1991 and Heisey and Brennen, 1991.

A division-wise disaggregation of the three most popular rice varieties among farmers also indicates that BR 28 and BR 29 are the most popular *boro* rice varieties in all but one division, while the 32-year-old BR 11 was the most popular *aman* rice variety in five divisions (Table 7.7).

Table 7.7: Most Popular *Aman* and *Boro* Rice Varieties by Division

District	Season	
	Aman	Boro
Barisal	1. BR 11 (Mukta)	1. BR 8 (Asha)
	2. BR 23 (Dishari)	2. BR 28
	3. BR 22 (Kiron)	3. BR 49
Chittagong	1. BR 22 (Kiron)	1. BR 28
	2. BR 11 (Mukta)	2. BR 29
	3. BR 23 (Dishari)	3. BR 16 (Shahi balam)
Dhaka	1. BR 11 (Mukta)	1. BR 29
	2. BR 25 (Noya pajam)	2. BR 28
	3. BR 22 (Kiron)	3. Hira
Khulna	1. BR 23 (Dishari)	1. BR 28
	2. BR 22 (Kiron)	2. Hira
	3. BR 33	3. BRI hybrid-1
Rajshahi	1. BR 11 (Mukta)	1. BR 28
	2. BR 22 (Kiron)	2. BR 29
	3. BR 49	3. Hira
Rangpur	1. BR 11 (Mukta)	1. BR 28
	2. BR 25 (Noya pajam)	2. BR 29
	3. BR 10 (Progoti)	3. Hira
Sylhet	1. BR 11 (Mukta)	1. BR 29
	2. BR 22 (Kiron)	2. BR 28
	3. BR 25 (Noya pajam)	3. Hira

Source: Authors, based on data from Ahmed (2013).

However, these figures should not be viewed as firm evidence that farmers are slow to adopt new cultivars in Bangladesh. Many of these other popular varieties have staying power precisely because of their superior traits, for example, yields and duration in the case of BR 28 and BR 29 (Hossain et al. 2013). Moreover, there is evidence from IFPRI's recent survey of the southern region of Bangladesh (IFPRI 2013) suggesting that farmers are experimenting with—and adopting—modern varieties that have been specifically promoted for their stress-tolerance traits. Since 2010, approximately 9 percent of farmers accounting for 3 percent of rice cultivated area have adopted at least one stress-tolerant cultivar (Tables 7.8 and 7.9). These varieties were developed by BRRI and BINA and promoted through several donor-funded research-for-development projects that specifically target southern Bangladesh.[5]

Table 7.8: Farmers cultivating Stress-tolerant Rice Varieties in Southern Bangladesh,[a] 2013

Variety	Percent of all farmers					Percent of rice cultivated area
	Marginal	Small	Medium	Large	All	
BRRI dhan BR-41 *(aman)*	0.00	15.63	13.21	13.16	12.74	0.29
BRRI dhan BR-43 *(aus)*	0.00	1.04	0.00	0.00	0.47	0.01
BRRI dhan BR-44 *(aman)*	4.00	2.08	0.00	7.89	2.83	0.05
BRRI dhan BR-46 *(aman)*	0.00	1.04	0.00	5.26	1.42	0.06
BRRI dhan BR-47 *(boro)*	28.00	10.42	15.09	21.05	15.57	0.47
BRRI dhan BR-48 *(aus)*	0.00	1.04	1.89	0.00	0.94	0.02
BRRI dhan BR-49 *(aman)*	20.00	16.67	16.98	18.42	17.45	0.41
BRRI dhan BR-50 *(boro)*	4.00	7.29	3.77	2.63	5.19	0.08
BRRI dhan BR-51 *(aman)*	0.00	6.25	3.77	10.53	5.66	0.18
BRRI dhan BR-52 *(aman)*	4.00	0.00	1.89	2.63	1.42	0.05
BRRI dhan BR-53 *(aman)*	0.00	0.00	0.00	0.00	0.00	0.00
BRRI dhan BR-54 *(aman)*	4.00	0.00	0.00	0.00	0.47	0.00
BRRI dhan BR-55 *(boro/aus)*	4.00	0.00	1.89	0.00	0.94	0.01
BRRI dhan BR-56 *(aman)*	0.00	0.00	1.89	0.00	0.47	0.02
BRRI dhan BR-58 *(aman)*	0.00	1.04	1.89	0.00	0.94	0.01
Bina-7 *(aman)*	36.00	38.54	35.85	18.42	33.96	0.96
Bina-8 *(boro/aus)*	0.00	1.04	1.89	7.89	2.36	0.08
Bina -10 *(aman)*	0.00	0.00	3.77	5.26	1.89	0.07
Bina -11 *(aus/aman)*	0.00	2.08	0.00	0.00	0.94	0.01
Bina -12 *(aman)*	0.00	1.04	0.00	2.63	0.94	0.02
All	4.64	9.26	12.05	9.90	8.83	2.79

[a] Southern Bangladesh denotes the "Feed the Future" zone of influence designated by the United States Agency for International Development (USAID). See http://www.feedthefuture.gov/country/bangladesh.

Note: Farm sizes are as follows: marginal farmers: less than 0.5 acres; small farmers: between 0.5 and 1.49 acres; medium farmers: between 1.50 and 2.49 acres; and large farmers: 2.5 acres or more.

Source: Authors, based on data from IFPRI (2013).

[5] These projects include the Cereal Systems Initiative in South Asia (CSISA) led by CIMMYT, and the Stress-Tolerant Rice for Africa and South Asia (STRASA). Donors include the Bill and Melinda Gates Foundation (BMGF) and the United States Agency for International Development (USAID).

Table 7.9: Share of Farmers Cultivating Selected Varieties for the First Time since 2000

Top 10 rice varieties	2009-2013		2004-2008		2000-2003	
	N	Percent	N	Percent	N	Percent
BR-28	148	7.55	200	13.52	168	13.47
BR-29	40	2.04	92	6.22	89	7.14
Guti Shorna	7.14	64	4.33	34	2.73	
BR-11 (Mukta)	56	2.86	57	3.85	54	4.33
BR-23 (Dishari)	56	2.86	56	3.79	47	3.72
BR-33	69	3.52	41	2.77	23	1.84
BR-39	89	4.54	32	2.16	10	0.80
Hira	38	1.94	65	4.39	24	1.92
Lal Shorna	32	1.63	18	1.22	32	2.57
BR-8 (Asha)	11	0.56	20	1.35	22	1.76

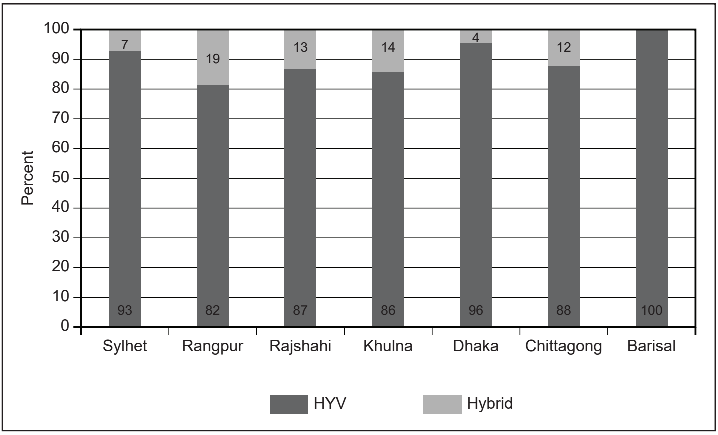
Source: Authors, based on data from IFPRI (2013).

Other indicators shed further light on the depth and breadth of the seed system's reach and performance in Bangladesh. Consider, for example, the small but significant share of *boro* rice cultivation that is attributable to hybrid rice. If hybrid rice is to play a role in increasing rice yields in Bangladesh, it is worth asking who is cultivating it at this early stage, and whether they are systematically different than other farmers who are yet to adopt. BIHS data indicate that hybrid rice is more prevalent among wealthier farmers, although variation across divisions seems relatively insignificant (Figure 7.4) (see also Spielman et al. 2012; Ward and Pede 2014).

Further evidence suggests that commercial input markets in Bangladesh are the primary source of seed for farmers. As shown in Figure 7.5, farmers rely on private dealers and retailers as their primary source for wheat and maize seed. However, a greater proportion of farmers cultivating rice and potato still rely on informal seed systems—own saved seed and exchanged seed. In the case of potato, seeds constitute more than 30 percent of the total cost of production prompting most farmers to use their saved seeds.

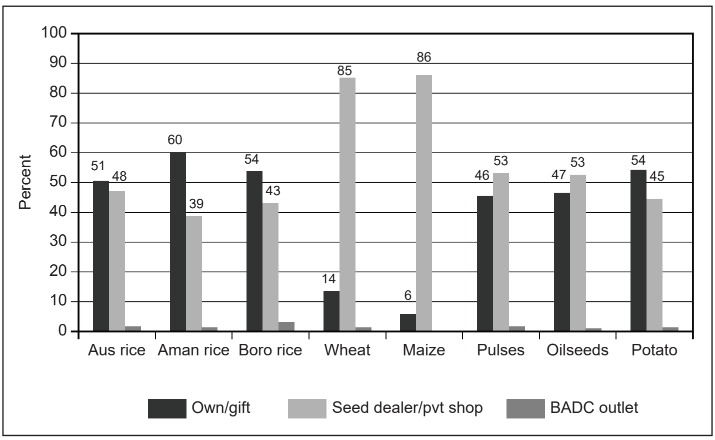
Figure 7.6 shows that seed purchases occur across all types of households, with purchased seed being as important for the poorest income quintiles as for the richest. However, as shown in Figure 7.7, a higher proportion of marginal farmers purchase seed compared to large farmers, where marginal farmers are characterized by an average farm size (based on operated land) of less 0.5 acres and large farmers by an average of 2.5 acres or greater.

Figure 7.4: Share of Farmers adopting of HYV versus Hybrid for Boro Rice



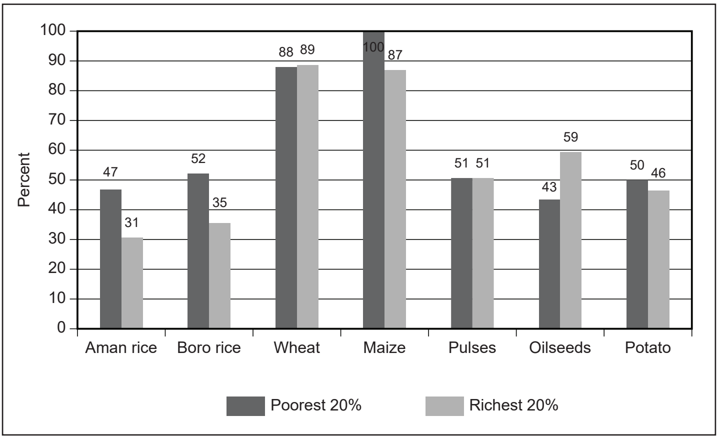
Source: Authors, based on data from Ahmed (2013).

Figure 7.5: Farmers' Sources of Seeds



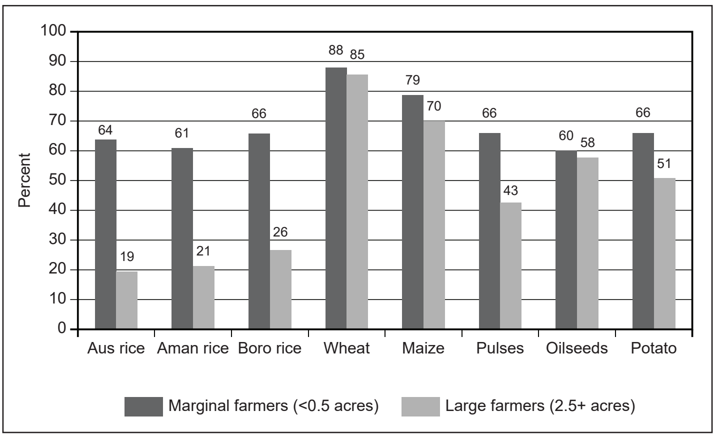
Source: Authors, based on data from Ahmed (2013).

Figure 7.6: Proportion of Farmers from Poorest and Richest Quintile who Purchased



Source: Authors, based on data from Ahmed (2013).

Figure 7.7: Demand for Commercial Seed by Marginal versus Large Farmers



Note: Differences in demand between marginal and large farmers are significant at 1% level for *aman* rice and *boro* rice; significant at 5% level for wheat, pulses and potato.

Source: Authors, based on data from Ahmed (2013).

7.5 Role of the Public Sector: BADC, NARS and DAE

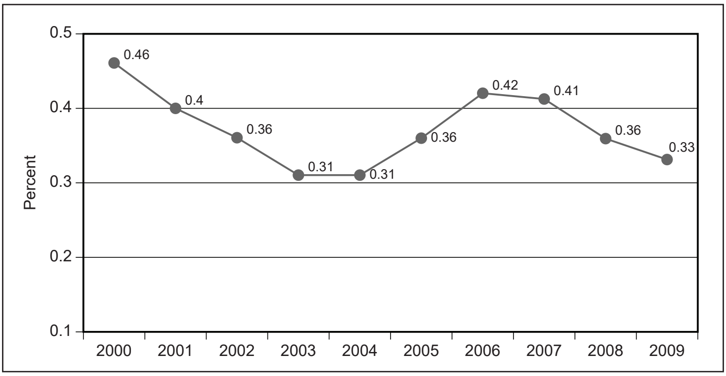
The public sector's role in Bangladesh's seed system revolves around three pillars: the BADC in seed production, the NARS for cultivar improvement, and the DAE for extension and advisory services. The most pressing issue regarding Bangladesh's seed system may be the role of BADC. In theory, the 1993 National Seed Policy aims to relegate BADC to the role of foundation seed producer for non-notified crops, thereby creating a financially viable public supplier of high-quality material to small- and medium-sized seed enterprises who can produce and market improved cultivars directly to farmers. This particular arrangement has been applied in India and other developing countries, and has contributed to the growth of private seed industries.

As noted earlier, there is evidence that BADC is increasing its production of foundation seed in compliance with the spirit of the policy. Yet there is also little evidence that BADC is withdrawing from the production of certified and truthfully labeled seed. BADC remains active in the production of certified and truthfully labeled seed for a wide range of crops, including hybrid maize where the private sector has a well-established comparative advantage. Meanwhile, BADC continues to price seed well below its costs of production, suggesting continued reliance on public funds to make ends meet.

For the research system, a key constraint is one of resources. Although investment in agricultural R&D (specifically cultivar improvement) has been repeatedly demonstrated to increase productivity and reduce poverty in developing countries, funding for the public research system in Bangladesh has been insufficient relative to the needs and expectations of the country. Agricultural R&D spending as a share of GDP from agriculture has hovered between 0.31 percent and 0.46 percent during the decade 2000-2009 (Figure 7.8). Though agricultural R&D intensity in Bangladesh compares favorably with India and Pakistan, it falls well below countries such as Malaysia, which spends more than 1 percent of its GDP from agriculture on R&D (ASTI 2014). This could serve as a useful benchmark for the level Bangladesh might reasonably expect its national research system to perform at in the future.

Agricultural research capacity has also deteriorated with the brain drain of qualified and experienced researchers. Moreover, the current generation of senior researchers is heading into retirement without adequate succession plans. Financing has been erratic and bureaucratic structures are inefficient and posts remain empty. Even though the allocation of resources for agricultural R&D has been inadequate, the actual expenditure since the past decade has been even less than the allocation.

Figure 7.8: Proportion of GDP from Agriculture Spent on R&D



Source: Authors based on ASTI (2014).

There is a second constraint that is more directly relevant to the seed system. Although the seed system is an important supplier of improved germplasm for state-owned seed companies and farms, many private sector firms and farmer organizations argue that they do not have equitable access to that same germplasm (Hossain et al. 2001). This limits the innovation pipeline from the research system to seed producers and, ultimately, to farmers in many countries. There is a need for both greater investment and deep structural reforms in the research system. This implies (i) strengthening public agricultural research focus on delivery of its improved varieties, i.e., widening the R&D pipeline with more and more frequent releases, and with increased access to breeder/foundation seed for all seed system actors, (ii) Increased, sustained investment in national research system, and (iii) reforms to research structures, management, funding systems.

Despite policy reforms in 1993, the playing field for the private sector remains uneven. BADC continues to rely on scarce public resources to produce, although there may be evidence that its reliance on private dealers and retailers for seed distribution might be one of the more impressive elements of its infrastructure. Still, BADC seems not to be backing into the foundation seed end of the business and using this position to stimulate the growth of small/medium-sized enterprises in the production and marketing of publicly bred self-pollinating cultivars. BADC may also be crowding out private investment in breeding, production, and marketing of certain crops, and it may be wasting scarce public resources by competing with the private sector in the maize seed market.

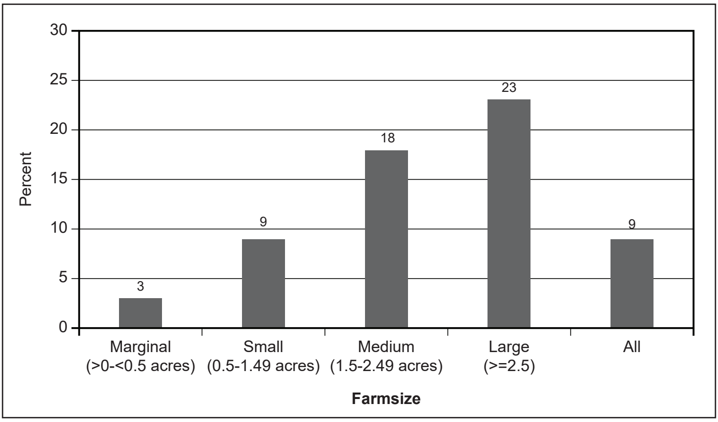
Another indicator of seed system performance is the extent to which information on new varieties is transmitted to farmers and through which channels. The transmission of information on new cultivars to farmers generally revolves around formal channels—primarily agriculture extension agents, nongovernmental organizations, and seed dealers—and more informal channels—social networks encompassing neighbors, friends, relatives, or other acquaintances. Despite the growth of more pluralistic extension system in line with the NAEP, the influence of the DAE has been minimal (Table 7.10). Farmer-to-farmer dissemination of information on issues such as crop variety, input dosages, and other advice seems to be the dominant channel, and just 7 percent of farm households surveyed by the BIHS were visited by an extension agent in the preceding 12 months. Barely 5 percent of farmers received advice on seeds, although almost all those who did receive advice found it useful. The provision of extension services agents appears to have a large-farmer bias (Figure 7.9).

Table 7.10: Availability of Agricultural Extension Services to Farmers

Extension activities	Farmers (%)
Visited by extension agent in past 1 year	6.9
- DAE worker	6.5
- Private/NGO worker	0.4
Received advice on seed	4.8
- Found advice extremely useful	32.5
- Found advice somewhat useful	66.0
- Did not find advice useful	1.5
Households from each farm size who received advice on seed:	
- Marginal farm households	1.4
- Small farm households	5.5
- Medium farm households	8.8
- Large farm households	11.2
Farmers visited by an extension worker	
- Single visit	31.0
- Repeat visits	69.0

Source: Ahmed (2013).

Figure 7.9: Percentage of Farmers Consulting Agriculture Extension Agent in Last One Year



Note: All means are significant at 1% level except for medium versus large farmers.

Source: Source: Authors based on Ahmed (2013).

In sum, the public sector in Bangladesh has been effective in provisioning improved rice varieties and hybrids—particularly for *boro*—but has been slow to replace the older cultivars for rice and wheat. Similarly, the private sector has played a central role in the rapid and relatively widespread introduction of hybrid maize. However, in the case of other, non-cereal crops such as pulses, legumes, and oilseeds, neither the public nor private sectors have played a significant role to date in developing or delivering new varieties.

7.6 Recommendations for a Reform Agenda

7.6.1 Strategic oversight and policy implementation

Public policy on seed needs to be based on empirical analysis rather than on pronouncements about quantities of seed provided or seed turnover rates. Many experts working on seed system reforms have pointed to the absence of centrally-managed, high resolution data and information on key seed system metrics like production quantities, technical performance parameters, market prices, and demand. Although there is a lot of information available from the monitoring and evaluation activities of many agricultural development organizations working all over the country, there is little coordination among these agencies. The outcome is fragmented, incomplete and difficult to access data with, sometimes, questionable reliability. Seed data from the government agencies is available but is, often, haphazard and user-unfriendly. For instance, to procure information on breeder seed production and supply disaggregated by variety, one has to approach the research institute itself. These are not available on the organizations' website. Even within the institutes, the data is scattered and one has to skim through reams of pages to access relevant data. There is no dependable information on the quantity of quality seed being marketed and the standard of the marketed seed. Again, there is no organized information on the farmers' actual uptake of different varieties and their experiences with the field performance. Such kind of information is critical for providing feedback to national breeding programs who can take these into cognizance for further breeding activities to develop farmer-friendly varieties.

In general, crop statistics in Bangladesh have often been criticized for being very limited and for their lack of reliability. Though the data on rice is comparatively much more detailed than that of other crops, questions have been raised from time to time about the credibility of the data. For instance, the official database, the Bangladesh Bureau of Statistics, shows the area under rice and wheat in 2007-08 was 26,130 and 958 thousand acres respectively. A census done by the same organization in that very year reports the corresponding statistics as 21,756 and 635 thousand acres—a difference of 20 percent and 51 percent, respectively. Such a wide difference in figures from the same source is bound to generate confusion among different stakeholders and, most importantly, lead to inappropriate policy actions. It is crucial to have an in-depth analysis of the current production trends, popular new varieties and amounts of seed to produce and deliver to farmers. The need is for better decision-making tools—better data, information, and analysis, and a more dedicated effort to lay the groundwork for development of a more commercial seed system. This entails a spatially-disaggregated, variety-specific data for major crops, information management systems and portals that make information available to all actors and clear policy messages in support of private sector development.

7.6.2 Creating a 'real' level playing ground—forging public-private partnerships

Many private firms argue that current trade and investment policies—including the crowding-out effects of BADC—inhibit their ability to operate in Bangladesh's seed markets. There is scope for a slow withdrawal of BADC from certified and truthfully labeled seed production and into foundation seed production for small- and medium-sized enterprises who, with some basic expertise and a relatively small amount of startup capital, can make seed production into a viable business venture. This is a fiscally responsible solution to strengthening the seed market, but it assumes that private firms and cooperatives will step in to fill the gap. One must tread cautiously since the open-pollinated crop reproductive biology may not provide sufficient incentives for private sector investment. That said, a withdrawal of BADC may work if accompanied by regulatory easing and business reforms that encourage private firms and cooperatives to invest in the seed industry. These reforms include easier loans, tax incentives and tariff reductions for importation of production equipment and materials, as well as targeted financing from the public or private sector to encourage the industry. Less attention can probably be given to those markets where private firms are more likely to concentrate, i.e., the higher-value market for hybrids or horticulture crops where farmers prefer to purchase high-quality seed each year. In these markets, the key is to maintain strong investment incentives by rationalizing the imposition of taxes, tariffs on imported equipment and materials, and ad-hoc non-tariff barriers that seem to be discouraging investment. This membership may bias decisions in favor of applications from public breeders and against applications from private or NGO breeders (Tripp and Louwaars 1997; CASEED 2013).

7.6.3 Reforming the seed regulatory regime

Stringent regulations, strict test standards, cumbersome procedures and slow processing tend to limit the number of improved cultivars that can be registered and put into production. New waiting-to-be released varieties have already been through a rigorous trial regime under the plant breeder. Yet another round of performance trials prior to their registration results in excessive delays. The SCA has very limited manpower and laboratories for seed testing. To make things worse, the skills for seed testing are specialized and repeated transfer of trained staff to other locations in the county often creates a void in the SCA. The varietal registration process could be rationalized through coordination among R&D institutions and the BADC, DAE, NGOs and seed companies during the variety testing and release process. This would help curtail duplication of efforts and make the process more time-efficient. For varieties that are registered and in use in neighboring countries with similar production environments, the requirement to register those varieties again when introduced in Bangladesh may be relaxed. Moreover, a harmonization of research for varietal testing among the different R&D institutes, along the lines that is prevalent in India, would ensure participatory testing of advanced lines across agro-ecological zones and facilitate movement of breeding material among the institutes. For performance testing, there is need for a greater participation by farmers' groups who are the ultimate decision makers of adoption of the variety best suited for specific environments. The All India Coordinated Crop Improvement Program, for example, is actively involved in Front-Line Demonstrations on improved technologies and is also organizing *Kisan Melas* for effective and speedy dissemination of newer technologies.

In the arena of seed quality control, the SCA is the principal regulatory body in Bangladesh, responsible for seed certification and market monitoring. The country saw a major policy change in 1998 when the mandatory provision for seed certification was relaxed to allow for truthful labeling and the private sector was allowed to market TFL seeds. Almost 80 percent of the seeds supplied to the farmers are TFL seeds and BADC markets the lion's share of these. BADC has its own internal quality control system but many private agencies are also selling TFL seeds with little capacity and capability for quality control. SCA has very limited capacity to monitor seed quality once it reaches the market and is purchased by farmers. With only 30 field officers and 6 regional seed testing laboratories, the organization is under-funded and under-equipped to perform the wide-ranging duties assigned to it. The SCA certifies not only foundation seed and certified seed but also breeder seed.

Studies have shown that breeder seed produced by plant breeders have adequate genetic purity that could be used for large scale multiplication of commercial seed (Parsons 1985; Tripp and van der Burg 1997). The SCA could save on its precious resources by focusing on the certification of foundation seeds. Reforming the SCA to make it a full-fledged independent department endowed with complete powers can make it functionally capable and technically sound. This can go a long way in seed system development in Bangladesh. Another option could be to have independent certification agencies that seed producers may contract voluntarily. This is the situation in the US where most seed certification is in the hands of agencies formed by farmer cooperatives or associations (Tripp and van der Burg 1997). The caveat here is that there must be sufficient demand to pay for the development of such a private service. Given the high probability that the benefits from certification will outweigh the losses of poor farmers from poor germination or other seed-related problem, such an initiative could be very successful in Bangladesh. An equally important element of seed quality control is to have strict penalties for fraudulent seed production and marketing and other activities that diminish the quality of the seed. This is an area often overlooked in Bangladesh.

To import any type of seed into Bangladesh, an import permit (issued by the Plant Protection Wing of the DAE) and a phytosanitary certificate from the exporting country are required. In addition, imported varieties of the five notified crops (rice, wheat, potatoes, jute and sugarcane) must be listed on the official list of varieties and must comply with the crop specific standards. To top these, are a series of tax and non-tax barriers that add up to the cost of private investment in the seed industry. Needless to mention, the final tax burden is on the farmer. An advance income tax of three percent is levied on imported rice seed. The tax structure for wrapped and canned seed is higher than unwrapped and un-canned seed with the result that latter group is more preferred by importers. The point of having a phytosanitary certificate from the country of origin is to ensure that the seed is good quality. However, on reaching the port, plant quarantine offices often want to conduct further checks on the quality of the seed that add up on the costs and time. Reforming the seed tax structure by easing of taxation, tariffs, and non-tariff barriers is crucial for overall seed sector development. Tax imposition should be reviewed in the light of quality seed supply at a cheaper price to the farmers; if feasible seed import should be exempted from taxes.

7.6.4 Reviewing and prioritizing research and development

There is an urgent need to review the current mandate of the agricultural research organizations to meet emerging needs and to rectify overlaps. The usefulness of the network of stations and sub-stations needs to be assessed including the possibility of closing redundant establishments. The deterioration of expertise must be checked and an appropriate pool of skill mix should be created. With growing populations, the strong need for increasing cereal productivity is understandable. But the rice-centric research efforts in Bangladesh have relegated other high-value nutrient-dense food crops to the background. Agricultural research should maintain a fine balance between the objective of continued food security for the masses and research and investment made for diversification out of primary staples. Farmers' flexibility in making crop choices must be made a priority through research at both the crop level and system level.

7.6.5 Tightening the role of agriculture extension

The extension agents are supposed to be the link between the farmers and the agricultural research stations but the reality is very different. There is a dire need to reform the extension service structure and delivery to fully exploit the benefits of the large, country-wide set-up that DAE already has. The financial sustainability of the extension services is often questioned—more than 90 percent of the annual revenue budget is spent on staff salaries while the operational funds for extension activities are largely provided by externally funded projects which serve specific objectives of individual projects (World Bank 2005). The cost-structure should be rationalized providing for relocating staff from places (where private extension services run parallel alongside public extension) to marginalised areas. The extension agents should give feedback on actual field experience to the research institutes and help provide the crucial link between the farmers and the R&D institutes. It is critically important to develop the capacity of the extension staff through appropriate trainings which enhance their understanding of the agro-ecologies and location-specificity of production conditions. The staff should also be incentivized through a system of performance-related rewards or bonuses. Finally, there is a need to have a greater involvement of the private sector in extension service provision that can complement the public service and, perhaps, aid in shifting some of the latter to more remote, marginalised areas.

7.7 Conclusions

The seed sector in Bangladesh has evolved significantly since the opening up of the seed industry in the early 1990s. From being predominantly dominated by the informal sector, the seed market has developed to a point where commercial seeds have assumed heightened importance. This has been the outcome of policy provisions that have shaped in response to changing needs. Though most seed is still produced by the farmers themselves, the new varieties are produced and distributed by government or commercial seed companies. With the advent of the Green Revolution, Bangladesh made a relatively early transition to using modern varieties of rice and wheat which ultimately was instrumental in improving food security in recent years. The country now requires facilitation to move on to stage 3 wherein the use of improved varieties spreads as the private sector begins to be a significant source of new technology. The policy framework is already in place in Bangladesh but the effective implementation of policy is still under development. Accelerating seed system development will require building strategic, implementable and effective public-private partnerships in all areas of action, starting from generation of data, research and development to the actual provisioning of seeds to farmers. Only then can we ensure a seed system that provides equitably and efficiently to all farmers.

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