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Seed, Fertilizer and Innovation in Bangladesh: Industry and Policy Issues for the Future

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EXECUTIVE SUMMARY

Bangladesh has achieved a remarkable success in food grain production in the recent past which has made the country nearly self-sufficient in food grain in normal years. Seed, fertilizer and irrigation technologies known as Green Revolution technologies have been playing major roles in the growth of agriculture production in Bangladesh. However, supply and markets of these modern inputs suffer from lot of uncertainties. During the past, lot of policy changes have been taken place to address these uncertainties, but lot more to be done to face the future challenges of food security. In this context, in relation to Bangladesh this piece of work mainly intends to investigate current structure of seed and agricultural input industry; current structure and impact of the public agricultural research and extension systems; scope for improving access to new technologies by the resource poor farmers and the policy options to improve the ability of small-scale, resource poor farmers to access, and benefit from new technologies. The study is based mainly on secondary data and published reports as well as focus group discussions with farmers, input dealers, traders, etc.

The review of input policy changes showed that prior to opening up the economy in the 1980s through the liberalization of the input markets, the Bangladesh Agriculture Development Corporation (BADC) alone handled the procurement and distribution of the inputs such as seed, fertilizer and irrigation equipment. However, subsidy based policies were debated on the grounds of price distortion, inefficient use of inputs and social barriers to access resources by poor, small and marginal farmers. The liberalized policies were thus prescribed by the International Financial Institutes like the World Bank and the International Monetary Fund without keeping any provision for the small and marginal farmers. The expectation was that the prescription would correct the above mentioned imperfections as well as this would lower prices of the inputs for farmers due to cheaper imports of inputs, which would translate to a reduction in the cost of production. However the expectation was not materialized and the previous problems were compounded by the liberalization of the agricultural input market.

Liberalization affected the input market on a number of different levels. There are many successes but inefficiencies in the input markets were also prevalent. Reforms at various levels in the fertilizer market have been taking place from the mid-1970s in regards to the privatization of sale, distribution and import of fertilizers. However, the impacts of these reforms can be visualized in the price hikes, unbalanced use of fertilizers (leading to over exploitation of natural resources) and adulteration of fertilizers. Farmers often lack fertilizers on time as well as lack quality fertilizers. In recent past, fertilizer crisis occurred in the years of 2005, 2007 and 2008. In order to mitigate crisis the government decided to bring the market under its direct control which again relaxed to open market system. Under severe crisis of fertilizer condition prevailing in Bangladesh, opportunity remains in the expansion of organic farming to reduce the use of chemical fertilizers. However, efficient use of organic sources along with chemical fertilizers needs to be further investigated.

In the seed sector, availability of quality seed is a big concern. Supply of quality rice seed is only about 40 percent of its demand. Again, out of total supply of quality rice seed, government organizations like BADC and DAE supply most of the quantity (84 percent) while the share of private traders and NGOs is considerably low (only 16 percent). BADC gets subsidy by the government which allows it to provide seeds at a lower cost. As the smallholder resource poor farmers have less access to BADC seed they have to depend on private sector for purchasing quality rice seed at a high price.

No institutional complementarity exists between public and private agencies between production and marketing of seed. Basic skill is also lacking in seed management with respect to research, extension, production and marketing which are

hindering increasing supply of quality seed. In this context, Biotechnology research is necessary along with socioeconomic research. Private sectors are investing in biotechnology and importation of hybrid seeds, but their scope is limited. Further, in the public sector research organizations like Bangladesh Rice Research Institute, Bangladesh Agricultural Research Institute there have been serious crisis of experienced researchers for production and management of quality seed.

In the case of irrigation, despite the contribution of the liberalization of small irrigation equipment to expanding irrigated areas, the poor and marginal farmers have lost access to this service due to steep prices. The import and distribution of inputs is primarily managed by the rural elites who rule the supply chain. Anyway, the problem of social conflict between so called 'water lords' and water buyers in recent years has reduced with expansion of small scale irrigation equipment, particularly Shallow Tubewells, many of which are now owned by small farmers also. However, there is lack of research to measure social costs and benefits of water use. Also, there is inadequate research on the current constraints on irrigation and the resulting consequences on farmers' income, farm productivity and poverty. Attention must be paid to broader analysis of irrigation performance in the context of scarcity and competing uses of water basins and understanding the irrigation-poverty nexus. Poverty and gender in irrigated areas is currently a subject of special research.

Comprehensive information on agricultural research conducted by the public and private sectors including NGOs is limited. Private sector is coming forward to conduct collaborative research with government research organizations but the extent is extremely limited. This type of collaboration should be encouraged through policy incentives. Extension services in Bangladesh are provided by the Department for Agricultural Extension (DAE), which has a strong organizational set up with trained personnel. In addition, public research cum extension organizations, donor supported rural development program, NGOs, private agro-chemical input suppliers, public community development and agricultural extension service providers, etc. are also involved in providing extension services. In spite of policy reforms and various attempts, the services provided by these stakeholders are not enough in the context of farmers' benefit. Large scale farmers perceive the DAE as generally not competent enough to provide advisory services necessary for commercialization. On the other hand, adoption of available technologies has not reached expected levels within the smallholdings which resulted in low productivity.

ABBREVIATIONS AND ACRONYMS

ADB	:	Asian Development Bank
AEC	:	Agricultural Extension Component
ASPS	:	Agricultural Sector Programme Support
ATC	:	Agricultural Technical Committee
BADC	:	Bangladesh Agriculture Development Corporation
BBS	:	Bangladesh Bureau of Statistics
BCIC	:	Bangladesh Chemical Industries Corporation
BCSIR	:	Bangladesh Council for Scientific and Industrial Research
BRRI	:	Bangladesh Rice Research Institute
CG	:	Contract Growers
CGIAR	:	Consultative Group of International Agricultural Research
DAE	:	Department for Agricultural Extension
DANIDA	:	Danish International Development Agency
DAP	:	Diammonium phosphate
DTW	:	Deep Tube Wells
FAO	:	Food and Agriculture Organization
FFS	:	Farmer Field Schools
FIAC	:	Farm Information and Advisory Center
GDP	:	Gross Domestic Product
GMO	:	Genetically Modified Organism
HYV	:	High Yielding Variety
ICM	:	Integrated Crop Management
IFOAM	:	International Federation of Organic Agriculture Movements
IMF	:	International Monetary Fund
IPR	:	Intellectual Property Rights
IRRI	:	International Rice Research Institute
KGF	:	Krishi Gobeshona Foundation
LLP	:	Low Lift Pumps
MOA	:	Ministries of Agriculture
MOP	:	Muriate of Potash
MT	:	Metric Ton
MV	:	Modern Variety
NAP	:	National Agriculture Policy
NARS	:	National Agricultural Research System
NATCC	:	National Agricultural Technology Coordination Committee
NATP	:	National Agricultural Technology Project
NGO	:	Non-Government Organization
NMS	:	New Marketing System
NSB	:	National Seed Board
NSP	:	National Seed Policy
OMS	:	Old Marketing System
PDP	:	Primary Distribution Points
PETRRA	:	Poverty Elimination Through Rice Research Assistance
SAAO	:	Sub-Assistant Agricultural Officer
SAP	:	Structural Adjustment Programs
SM	:	Seed Multiplication
SPC	:	Seed Processing Center
SSP	:	Single Super Phosphate
STW	:	Shallow Tube Well
TIP	:	Thana Irrigation Project
TSC	:	Thana Sale Centre
TSP	:	Triple Super Phosphate
TV	:	Traditional Variety
UNDP	:	United Nations Development Program

INTRODUCTION

Background of the study

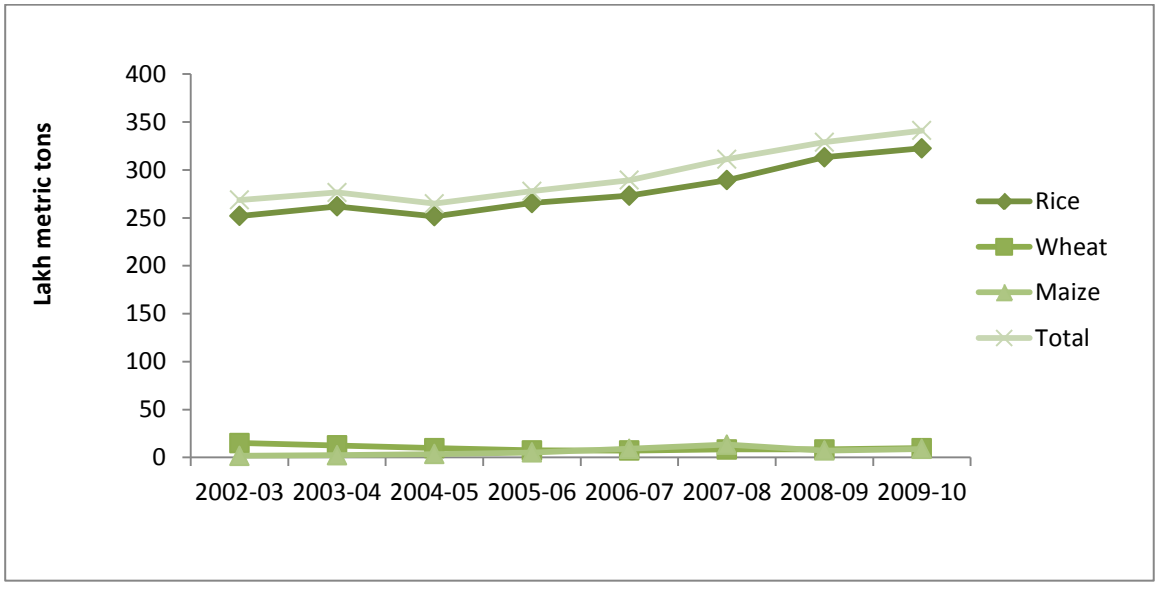
The growth of the agriculture sector is vital to ensure food security, one of the primary goals of the National Agriculture Policy (NAP) of Bangladesh. Agriculture contributed 19.3 percent to the GDP of Bangladesh in 2010-11 while crop sector alone contributes 10.9 percent (CDP, 2011). In the crop sector, rice crop is dominant crop occupying about 75 percent of crop land and supplying 70 percent calorie intake for the people of Bangladesh.

In the past, the country was largely dependent on importation of food grains as the production of rice lagged behind demand for the increasing population. With large scale adoption of new technologies (HYV seed, fertilizer and irrigation) coupled with agricultural input policy changes and market liberalization which started at the end of 1980's, the production of rice production tripled since independence and in the normal years Bangladesh achieve nearly self-sufficiency in food grain. The increase in rice production is largely due to conversion from traditional rice to MVs (Baffes and Gautam, 2001; Ahmed 2004) and the main contribution came from HYV Boro compared to other two types of rice (Aman and Aus) as can be seen from the Figure- 1.

In the present decade the production of rice has increased at the rate of 3.65 percent (BBS 2009) against current growth of population at 1.35 percent. As a result per capita rice production has shown sharp increase during the last 15 years, thus contributed to reducing food grain deficit substantially. Therefore, Bangladesh has made remarkable progress in achieving its food security. Though there were ups and downs, production of food grain, particularly rice generally experienced an upward trend.

Seed, fertilizer and irrigation technologies known as Green Revolution (GR) technologies have been playing major roles in the growth of agriculture production in Bangladesh. Fertilizer inputs grew from 8.8 kg of nutrients per hectare in 1968 to 238 kg. per hectare in 2009-10 (Bangladesh Economic Review, 2010), pesticide use from 2,200 tons in 1982 to 10,367 tons in 2003 (MOA, 2008; Rahman, 2007); and modern irrigation rose from 8.2 percent of gross cropped area (GCA) in 1968 to about 42 percent in 2009-10.The production of rice crop, particularly Boro demands intensive and judicious uses of inputs like modern varieties of seed, fertilizer and irrigation; the supply and markets of which suffer from lot of uncertainties.

FIGURE 1. RICE PRODUCTION COMPARED TO OTHER TYPES OF FOOD GRAINS IN BANGLADESH: 2002-03 TO 2009-10



Source: Bangladesh Economic Review, 2010.

With the above background, this study is an in-depth analysis of the seed, fertilizer, and agricultural inputs industry in Bangladesh. Specific emphasis is given to the country's major cereal crop (rice) and the secondary cereal crops (wheat and maize), the regions in which these crops are cultivated, and the types of farmers and farming systems that stand to benefit (or loss) from technological advances introduced by the public and private sectors. The analysis draws on available secondary data from government and industry statistics, search engines, data and analysis from scholarly publications

available in accessible databases (Google Scholar, JSTOR, etc), Grey Literature, and other credible sources of data, information, and analysis. Focus group discussions with farmers, and dealers of fertilizer, seed and agricultural machineries were also conducted in connection with this study.

The analysis specifically addresses the following questions:

- What is the current structure of the seed and agricultural inputs industry in Bangladesh, particularly with respect to competition and innovation?
- What is the current structure and impact of the public agricultural research and extension systems in Bangladesh, and how do these public systems contribute to improving the ability of small-scale, resource- poor farmers to access new technologies?
- How does industry structure affect the ability of small-scale, resource-poor farmers to access new technologies?
- What policy options can be introduced to improve the ability of small-scale, resource- poor farmers to access, and benefit from new technologies?

In order to address these questions the following topics and related issues were analyzed in details:

- The sources of research, development, and innovation in Bangladesh agriculture, including public agencies, private companies, and non- governmental organizations.
- The role of intellectual property rights (IPRs), plant variety protection, and IPR enforcement in the Bangladesh's seed and agricultural biotechnology.
- The role of Bangladesh's bio-safety, biodiversity, trade, and investment policies and policy environment with respect to both agriculture and agricultural biotechnology.
- The role of competition and competition policy with respect to the seed and agricultural inputs industry.
- The role and influence of other industry, specific issues in Bangladesh related to the seed and agricultural inputs industry.
- Policy options being considered and policy options not yet designed by public and corporate decision-makers to expand access to improved seed and biotech products in a manner that encourages the development and delivery of technologies for smallholders.

AGRICULTURAL INPUTS IN BANGLADESH

Overview

The role of seed, fertilizer and irrigation can be considered a major push behind the positive stride of agricultural development in Bangladesh. This section analyses the growth, present situation and constraints of these technologies and their link with research, extension and markets.

Agricultural Input Industry in Bangladesh: marketing and distribution

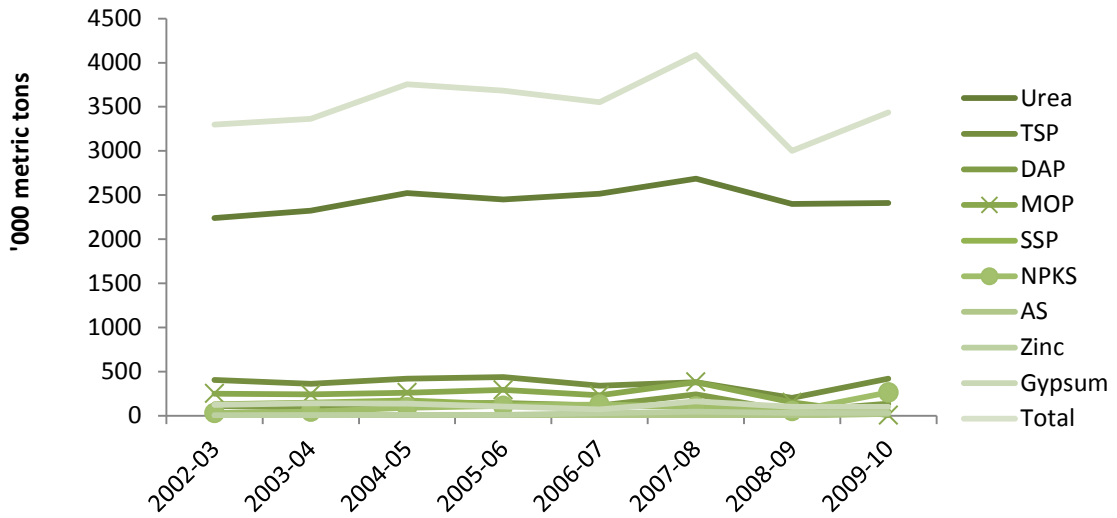
Immediately after Independence in 1971, Bangladesh was following a public-sector led growth strategy in all sectors of the economy. In the agriculture sector Bangladesh Agricultural Development Corporation (BADC) was given monopoly power for the procurement and distribution of subsidized agricultural inputs such as seed, fertilizer, irrigation equipment etc. However, in the 1980s, as part of the Structural Adjustment Programs (SAPs), advocated by the World Bank and IMF, the private sector was allowed to procure and distribute inputs, import food grains and the subsidies were gradually being withdrawn. This liberalization and privatization policy of the government was blamed for the adverse effect on the poor and marginal farmers (Titumir and Sarwar 2006). It was claimed that the ultimate beneficiaries of this liberalization policy were the local elites, rich landlords and the multinational companies.

Fertilizer

Fertilizer Use and Supply Overtime

In a land-scarce economy like Bangladesh, yield-increasing and land saving inputs like fertilizer and high yielding varieties (HYVs) are substituted for land. Chemical fertilizers were introduced into the Bangladesh Agriculture in the late 1950s by the public sector. Since then the demand has been growing sharply with the increase in production through HYVs. Consumption was 1 million tons in 1983-84, which reached to a maximum of about 4.1 million tons in 2007-08 and then decreased to a level of 3.4 million tons in 2009-10 (Bangladesh Economic Review, 2010). Along with urea, phosphate and potash - the uses of gypsum, zinc sulphate, and other micronutrients have also been increased. However, there is a big gap in the use of Urea compared to Triple Super Phosphate (TSP) and Murite of Potash (MOP) as well as other types of fertilizers (Figure- 2).

FIGURE 2. FERTILIZER USE BY DIFFERENT TYPES IN BANGLADESH: 2002-03 TO 2009-10

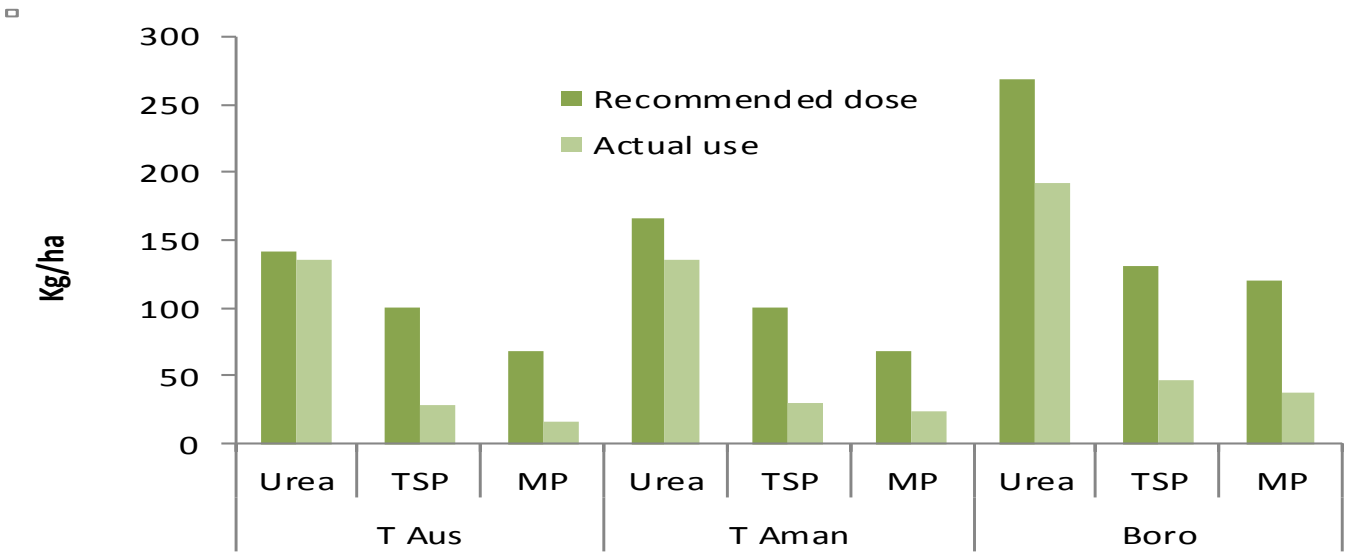


Source: Bangladesh Economic Review, 2010

The gap also exists in the case of recommended dose and actual use of fertilizers. In this case also, the gap between recommended dose and actual use of TSP and MOP is much higher for TSP and MOP compared to Urea (Figure- 3). For example, in the case of Urea for *Boro* paddy production while the gap between the recommended dose and actual amount of fertilizer used was 28.62 percent in 2004, the gaps for TSP and MOP were 64.12 percent and 69.42 percent respectively (MOA, 2004).

The share of Urea in total use of fertilizer remains high and almost same over the period, accounting for 67 percent of the total use of fertilizer in 2004-05 compared to 69 percent in 1992-93. Beside the promise of lower fertilizer prices, the liberalizers argued that availability of different types of fertilizers due to the internationalization of the market would lead to balanced and sustainable use of fertilizer in the fields. It was also expected that affordable price and availability of fertilizer will induce the use of different types of fertilizer whereas it was confined into some specific types like Urea earlier. The official statistics on sale of fertilizer of different varieties do not lend support to the above-mentioned contention; rather they suggest a disproportionate use of fertilizers, with obvious pressures on the fertility of land.

FIGURE 3. RECOMMENDED AND ACTUAL USE OF UREA, TSP AND MOP IN BANGLADESH, 2004



Source: Agriculture Sector Review, MOA, 2004

This suggests that the liberalized regime could not help the use of other fertilizer at an expected rate due to higher prices of those types, though these were promised to below. The gap between the recommended dose and actual amount of fertilizer application is very high in the cases of TSP and MOP. Due to unbalanced use of fertilizer, the loss in soil fertility is also significant in Bangladesh (Chowdhury and Uddin, undated). In order to encourage balanced use of fertilizer to augment production, subsidy on import cost of TSP, DAP and MOP was reintroduced in FY 2004-05.However, the price of non-Urea fertilizers is still much higher compared to Urea even after subsidy. Thus, it was found that neither the privatization policy nor the fertilizer subsidy guaranteed balanced use of fertilizers.

In Bangladesh Urea, TSP and Single Super Phosphate (SSP) are partially produced in the local industries, which can partly meet the total demand of the country. Additional requirements of Urea, TSP and Gypsum are met from import. Bangladesh Chemical Industries Corporation (BCIC) is responsible for the operation of 6 urea plants and one TSP plant in the country. The private sector imports non-urea fertilizers namely TSP, MOP and DAP.

Bangladesh Agriculture Development Corporation (BADC) has been involved in the fertilizer marketing again from 2006. Since then 50 percent of the import of TSP and MOP has been done by BADC, the rest by the members of Bangladesh Fertilizer Association (BFA).According to BFA sources, during the year 2006-07, .36 million MT of TSP was imported by the private sector while.12 million MT was imported by BADC. In 2008-09, 237,000 MT was imported by the private sector and 168740 MT by BADC.

Fertilizer Marketing and Distribution System

The changes/reforms those have been taken place in the marketing and distribution system of fertilizer since the liberation of Bangladesh is shown in Table- 1. The fertilizer sector remained under the complete public sector control until 1970s. The system was known as Old Marketing System (OMS). The government operated the system of its procurement and distribution through parasitical institutions. Policy instruments used under this monopoly system were fertilizer subsidy, regulated trade and controlled prices. The OMS was considered to be inefficient and unsuccessful. So the New Marketing System (NMS) was set up at around 1977-78. The implementation of the privatization policy under the NMS began in the early 1980s (Ahmed 1995, Ahmed et al. 2000). The government then allowed the private sector to import fertilizer. The subsidy on fertilizers was withdrawn completely by 6 December, 1992 and fertilizer trade was privatized. Along with importation, distribution of fertilizer was made open.

During the regime of liberalized fertilizer marketing system, the farmers claimed that in most cases they found the fertilizer adulterated fertilizer sacks contained less than the specified quantities. The farmers thus paid higher prices for lower quantities. They were of the opinion that the fertilizer market was hostage to low quality fertilizers, imported mainly from India and China for higher rate of return by the importers. The Ministry of Agriculture in their review also acknowledged the issue of rampant contamination in fertilizers. Usually fertilizers are contaminated through mixing of substances like the micro-

granules of particular fertilizers. In case of TSP, red contaminants like cracked bricks are mixed with the actual granules which are usually inseparable by the poor farmers from actual one (Chowdhury and Uddin, undated).Control measures were re-introduced in 1996 due to the failure of the privatized system to make the market competitive.

Prior to 2007 fertilizers were sold and distributed by some 4500 dealers registered with the Bangladesh Chemical Industries Corporation (BCIC). In order to make the fertilizer distribution system easier and fruitful, government appointed some sub-dealers at the union level all over the country in 2007. The government also introduced a system called the slip system and allotment slips were issued to the farmers by the chairman, members and Sub-Assistant Agricultural Officers (SAAOs) in their respective unions. The slips system allotments were discriminatory because some farmers managed to collect more slips and so got more fertilizers. Thus some others were deprived of getting required amount of fertilizers as they were not accessible to the allotters of slips. As a result government has introduced a new system in *Boro* 2009 season, where SAAOs conducted household surveys and prepared 'Farmers' Register' with data of each household including their cultivating crops and areas by season. In addition, each household has been provided with a printed `Fertilizer Distribution Card' with records of their crops and cultivation area by season. Fertilizer distribution was made on the basis of information recorded and recommendations of the SAAOs. On the day of distribution each farmer was obliged to go to dealers' shops where SAAO checks into the 'Fertilizer Distribution Card' and farmer's 'Fertilizer Distribution Register' lying with the dealer and gives allotment of fertilizers to the farmers on the spot. The new system is more objective than the previous systems; farmers cannot purchase fertilizer in excess of their requirements. The prices were fixed by the government and selling fertilizer outside the union was prohibited.

Although the mechanism greatly facilitated the availability of fertilizer to all farmers, the system is time consuming and may be expensive too. The farmers have still expressed their aversion to the system as they are required to spend long time in the registering process. Farmers prefer to purchase fertilizers from the open market.

Under the above circumstances, fertilizer distribution system has again changed as revealed from the recent field survey among farmers and dealers. According to the current distribution system of fertilizers, the distribution systems for Urea and non-Urea fertilizers are different. There are fertilizer dealers in every union of the country (one dealer for each union). The dealers buy Urea at fixed government price from Bangladesh Chemical Industries Corporation (BCIC). There are quotas for the dealers regarding the quantity of Urea they can buy. Then they sell the Urea to sub-dealers according to their requirements. There is one sub-dealer in one ward (nine for each union). The sub-dealers then sell Urea to the farmers. There is no fixed quota or quantity for selling Urea to the farmers but the price is fixed by the government. Some other traders/retailers also buy Urea from the dealers and sell in the open market. In the case of non-Urea fertilizers, the dealers buy fertilizers from the open market and sell to sub-dealers and retailers. The sub-dealers/retailers sell fertilizer to the farmers in the open market at market price.

There has not been any reported fertilizer crisis after introduction of the open market system as revealed from farmers responses from the field survey. Previously when Urea had to be purchased directly from the dealers, there were crisis in the availability of fertilizers some times as reported by the farmers. The farmers expressed their opinion that the availability of fertilizers is not a problem at present, but the prices of fertilizers are too high.

TABLE 1.CHANGES IN FERTILIZER MARKETING AND DISTRIBUTION SYSTEMS INBANGLADESH SINCE MID70S

Year	Areas of Reform	Measures Taken
Mid 70s	Fertilizer Distribution system	Replacing OMS (old Marketing System) by NMS (New Marketing System). From total public sector monopoly to largely competitive free marketing system.
1982-83	Pricing of fertilizer	Farm level prices were decontrolled by April1983.Largely replaced the BADC's retail trade of fertilizer.
1984-85	Privatization of sale of fertilizer	By July 1985, BADC closed almost all 423 Thana Sale Centres (TSCs). By mid1988, 8000 wholesalers and dealers lifted (collection of fertilizer by the dealer from the distribution point) 97 percent of the total quantity of fertilizer sold from Primary Distribution Points (PDPs).
March, 1989	Private sector lifting from factory/ farm ends	Government allowed direct sales of urea from all five factories beginning March 14, 1989. The government also allowed the distributors to lift TSP and MP from port/ factory.
1992	Privatization of import	The government excluded fertilizers from the list of restricted imports and allowed the private sector to import fertilizer. The subsidy on fertilizers was withdrawn completely in

		December 1992 and importation and distribution of fertilizer made open.
1995	Reversal of Urea Marketing policy	The open market system for domestically produced Urea experienced asset back in 1995. Government decided to bring the market under its direct control to mitigate the ensuing crisis reintroducing controls on the marketing and distribution of Urea.Urea
1996	Re-introduction of fertilizer subsidy.	The subsidy on the imported fertilizer was introduced for the first time.
2007	Urea Crisis	Introduction of slip system
2008	Urea Crisis	In the dealership policy 2008, by cancelling *Upazila* based system, provision was made for appointing at least one dealer for each union.
2009	Urea Crisis	In the new dealership policy introduced in 1st October 2009 modified dealership system 'Farmers' Register', 'Fertilizer Distribution Card' and 'Fertilizer Distribution Register' were introduced.
2010	Open market sale re-introduced	'Fertilizer Distribution Card' and 'Fertilizer Distribution Register' are no longer prevailing. Farmers purchase urea from the sub-dealers at a price fixed by government while they buy non-urea fertilizers from the open market at market price.
2012	Substantial subsidy for non-urea fertiliz-er	Price of non-urea fertilizer drastically reduced. Price of TSP per Kg. subsidized from Tk. 80 to Tk. 22, MOP from Tk. 70 to Tk. 15 and DAP from Tk. 90 to Tk. 27.

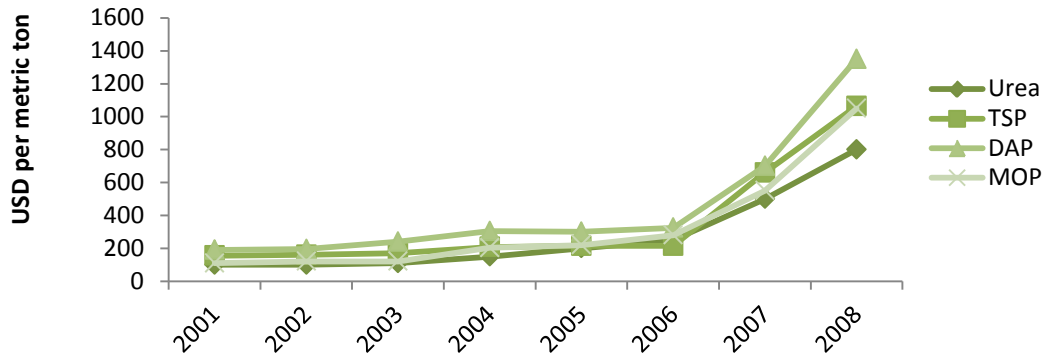
Source: Titumir and Sarwar,2006; Chowdhury and Uddin, undated; Barkat et al., 2010; and Jaim, 2012.

Privatization and Fertilizer Crisis

Studies claim that the objective of liberalized fertilizer market was not realized. Instead of developing a competitive free market, it is a common phenomenon for the fertilizer price to soar when fertilizer is very crucial to the farmers. The farm gate price has rocketed up and up, particularly during the period when fertilizer is necessary for crop production (Chowdhury and Uddin, undated). For example, urea price increased annually by 2 percent during 1990-91 to 2004-05, while the rise in the case of TSP and MOP was 187 percent and 180 percent respectively. The price hike was due to increase in price of fertilizers in the international market (Figure- 7) as well as syndicated and oligarchic behavior by importers and distributors (Chowdhury and Uddin, undated). The price of TSP in the market averaged Tk. 1000 / 50 kg and Tk. 800 / 50 kg in case of MOP in 2005-06, though the price was supposed to decrease as the government provided import subsidies in the FY 2005/06 at a rate of 25 percent on invoice. The import subsidy was introduced for the first time in 2005/06 in the backdrop that the prices of imported fertilizers like TSP and MOP increased sharply relative to that of domestically produced urea during the reforms period and aftermath. So, it is a kind of policy reversal from the so called liberalization measures aimed to discontinue sharp price rise of imported fertilizers (Chowdhury and Uddin, undated).

In the past, Bangladesh witnessed fertilizer crisis in the years of 1974, 1984 and 1989. Although the open market system for domestically produced urea experienced a major setback in 1995, fertilizer crisis continued. In recent past, fertilizer crisis occurred in the years of 2005, 2007 and 2008.In order to mitigate crisis the government decided to bring the market under its direct control. The control measures were reintroduced on the marketing and distribution of urea in 2010 which again withdrawn in 2011 and non-urea fertilizer prices are now available at a heavily subsidized price (Table- 1).

FIGURE 4. TREND OF INTERNATIONAL PRICES OF DIFFERENT TYPES OF FERTILIZERS AND RECENT PRICE HIKES



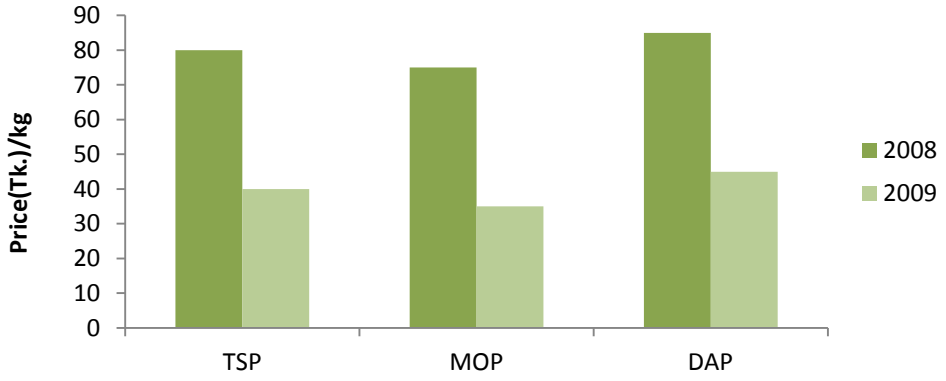
Source: Kafiluddin, 2008

Fertilizer Subsidy and Private Sector Actors in Fertilizer Market

Over time, import cost of fertilizers experienced significant increase when there was rise in the price of fertilizer in the world market and cost of local urea production also accelerated. Government reintroduced the subsidy for imported products. In 2007 for each ton of urea costing Tk. 31,000, a subsidy of Tk. 25,700 was given. During the year 2007-08, Tk. 3,120 crore was provided for urea, whereas Tk.486 core for TSP, DAP and MOP.

During the beginning of *Boro* season of 2009, government again subsidized the price of fertilizer. The prices of non-urea fertilizers were slashed to almost half per kilogram to help farmers during the *Boro* season (Figure-5). Non-urea fertilizer prices were further reduced beginning of *Boro* season of 2012 (Table- 1). The aim of the government was to reduce the production cost of rice for the farmers and make fertilizer more easily available to the poor farmers. Allegations have been raised that the price cut of fertilizer has benefited the businessmen rather than the poor farmers as the price of fertilizers had already decreased in the international market. Again, there has been complaints also that in some places non-urea fertilizer had been sold at the previous price, without the enforcing the subsidized price. It was also evident that neither the privatization policy nor the fertilizer subsidy guaranteed farmers proper use of fertilizer causing unbalanced use of fertilizer, deficiency in micro nutrient and organic matter, depletion of soil nutrient, etc. The extent of damage is yet to be examined.

FIGURE 5. PRICES OF NON-UREA FERTILIZERS IN 2008 AND 2009



Source: Chowdhury and Uddin, undated

Organic Farming and Fertilizer Demand

Organic farming is one of the fastest growing farming practices in the world but the base is still very low. Opportunity to expand the practice may be enormous. Expansion of organic farming may reduce the use of manufactured fertilizer (Islam 2006) but this may be very early to generalize this view. Fertilizer demand and cereal production is almost linearly correlated, and using manufactured fertilizer in the rate is considered a threat to environment. However, application of organic fertilizer may not be a solution. Disadvantages include high labor and transport costs, extra burden to land for biomass production etc. Manure, municipal sewage, sludge etc. used for organic fertilizer also contain hazardous substances like arsenic. Leaching of substantial amount of nitrate, acid soluble zinc etc. are also common from organic sources. China is an example of high user of organic fertilizer in the 1950s but gradually moved to the user of chemical fertilizer (Chen et al. 1998).

Recently, bioslurry is getting popularity as a source of organic fertilizer. Bioslurry is an anaerobic digested organic material released as byproduct from the biogas plant after production of combustible methane gas for cooking, lighting and running machinery. The organic materials generally used in Bangladesh as raw materials for biogas plant are cow dung, poultry litter and other easily decomposable materials such as kitchen refuses, farm wastes, water hyacinth, and crop residues. Night soils or human excreta are also used for producing biogas, although there is some social reservation to utilize them. Bioslurry is a 100 percent organic fertilizer most suitable for organic farming for some high value field and horticultural crops (Islam 2006). It is claimed that bioslurry organic fertilizer is environmental friendly, has no toxic or harmful effects and can easily reduce the use of chemical fertilizers up to 50 percent. Nutrients from organic sources are more efficient than those from chemical sources.

There were 25000 biogas plants in Bangladesh in 2006 as reported by Islam (2006). These plants had the capacity to produce 200,000 tons of bioslurry, which is equivalent to 9000 tons of urea plus 25,000 tons of TSP plus 3200 tons of MOP and other fertilizers. Islam (2006) claimed that the country has the potential to increase the number of biogas plants to 4 million to solve the fertilizer crisis. The claim is yet to be fully explored. This is an area which requires further research.

Seed

Overview

Seed is the primary agricultural input. In case of rice, historically, Bangladesh had about five thousand rice varieties; however, recent rice varietal survey in 2005 showed the existence of 1071 varieties in Bangladesh (Hossain and Jaim, 2009). Since the green revolution in the 1960s and afterwards, high yielding and modern varieties (HYVs and MVs) were introduced and gradually expanded with the patronization of the ministry of agriculture. So far, Bangladesh Rice Research Institute (BRRI) has developed 54 rice varieties; some of these became extremely popular. For example, Brridhan 29 and Brridhan 28 are the most popular varieties in Dry/*Boro* season covering 37 percent and 23 percent respectively while BR-11 is the most popular variety in Wet/Kharif season covering 27 percent of rice area as revealed from rice diversity survey in 2005 (Hossain and Jaim, 2009). The other research organizations (i.e. Bangladesh Institute of Nuclear Agriculture) and Universities (i.e. Bangladesh Agricultural University) as well as some Non-Government Organizations (NGOs) like BRAC are also contributing to development of HYVs as well as Hybrid varieties of rice. For example, BRAC has developed 8 Hybrid varieties of rice. The HYV varieties along with Hybrid varieties although rightly met the increased demand for food; these have however, replaced a large number of traditional local varieties; some of these might have sources of important strains necessary for sustainable production. In 2005, the number of extinct varieties as reported by the farmers was 572 varieties in *Aman* season and 426 varieties in *Aus* season (Hossain and Jaim, 2009).

However, supply of quality seed compared to demand is inadequate in Bangladesh. In 2007-08 the supply of quality rice seed was 118500 metric ton against the demand of 306840 metric tons. That is, supply of quality rice seed was only 39 percent of its demand. Therefore, rice production can be increased easily by 10-15 percent by increasing supply of quality seed. Among different sources of quality seed BADC and DAE supplied about 15 percent and 17 percent respectively in 2007-08 while private dealers/traders and NGOs supplied only 6 percent of the demand. Again, out of total supply of quality rice seed, BADC and DAE supplied 84 percent of total supply while private traders and NGOs supplied only 16 percent which indicates major sources of quality rice seed is government organizations.

TABLE 2. DEMAND AND SUPPLY OF QUALITY FOOD GRAIN SEED SUPPLY IN 2007-08 (IN M. TON)

Food grain type	Demand for quality seed (m. ton)	Supply of quality seed (m. ton)						
		BADC	DAE	BRRI	BARI	Private / NGO	Total	Supply as % of demand
Rice	306840	47090 (40%)	52500 (44%)	110 (<1%)	-	18800 (16%)	118500 (100%)	39
Wheat	70800	21000 (54%)	18000 (46%)	-	216 (<1%)	-	39200 (100%)	55
Maize	5000	470 (10%)	-	-	9 -	4500 (90%)	4970	99

Note: Figures in the parentheses indicate percentage of total supply

Source: BADC, 2011

In the case of wheat, supply of quality seed is 55 percent of the demand. BADC and DAE supply almost 100 percent of the quality wheat seed in Bangladesh. In the case of maize almost 100 percent of the demand of quality seed is supplied. However, only 10 percent of maize quality seed is supplied by the government (BADC) while 90 percent is supplied by private sectors / NGOs. BRAC alone supplies about 50 percent of the maize seed. BRAC has also contributed to developing 2 Hybrid varieties of maize.

A number of reasons are responsible for hindering increasing supply of quality seed. Seed technology is a modern science and in Bangladesh, basic skill is lacking in seed management with respect to research, extension, production and marketing. Further, for maintaining seed quality, facilities for seed processing and preservation are inadequate in Bangladesh. To assess seed quality some small equipment with laboratory facilities are essential which is extremely lacking in

Bangladesh. At present, Seed Certification Agency has two laboratories and BADC has 25-26 laboratoriesincluding one Central Laboratory. In the private sector, there is also one laboratory owned by an NGO. Taking the advantage of inadequate number of seed testing laboratories many seed companies and businessmen declare their own seed as good quality and selling it in the market with a label of tested good seed on the packet. To manage the problem, Seed Certification Agency by this time established 25 mini laboratories in different regions of Bangladesh and a proposal of reorganizing Seed Certification Agency is under active consideration of the government.

The National Seed Policy (NSP) of 1993 and Seed Rules of 1998 made a number of provisions that could guarantee quality of seeds either produced domestically or imported (Agriculture Sector Review, 2006):

- First, any variety whether imported or domestically developed, must be registered with the National Seed Board (NSB).
- Second, all private dealers involved with seed import, registering new seed variety and packaging seeds in label containers, must be registered.
- Finally, all varieties of seed must be certified by Seed Certification Agency (SCA).

However, these rules are not properly followed by most of the seed companies and businessmen.

Sources of Rice Seed Supply

Rice seeds used by the farmers can be broadly classified into four groups:

- Modern Varieties (MV) of Bangladesh origin
- MV of Indian origin
- Hybrid and
- Traditional Variety (TV).

Findings from field survey (Hossain and Jaim, 2009) revealed that farmers used Bangladeshi MV of rice in about two-third (64 percent) cases. Indian MV was used in about 10 percent cases while Hybrid seed was used in less than 2 percent cases (1.67 percent). On the other hand, TV of rice seed was used by about a quarter of the farmers (24.36 percent cases).

TABLE 3. USE OF RICE SEED BY THE FARMERS BY BROAD SEED VARIETY GROUPS

Broad seed variety groups	No. of cases of seed use	% of all
MV (Bangladeshi)	35332	64.00
MV (Indian)	5501	9.97
Hybrid	922	1.67
TV	13447	24.36
All	55202	100.00

Source: Hossain and Jaim, 2009.

In the case of Bangladeshi MV, the main source of seed supply was found to be own harvest (52 percent) followed by BADC / DAE (25 percent), neighbors (14 percent), dealers (9 percent), etc. (Hossain and Jaim, 2009). Therefore, government sources like BADC/DAE had important role in supplying MV of seed to the farmers. The farmers who used Indian MV, main source of their seed was own harvest (72 percent) followed by neighbors (21 percent) and dealers (9 percent). On the other hand, the main source of Hybrid varieties was found to be seed dealers (60 percent).In the case of TV, main source was own harvest (82 percent) followed by neighbors (15 percent) and dealers (4 percent).

Seed Production and Marketing

Seed system in Bangladesh may be classified as traditional or informal, semi-formal and formal. In the informal system, farmers themselves save seeds for next season from their current season harvest or acquire seeds through informal trade and exchange. In this system quality control measures are informal, inherited from their ancestors and improve from their

experience. This is the major source of supply but quality is reported to be lower than the formal system (Najrul et al. 2010). The Bangladesh Agricultural Development Corporation (BADC) bears the main responsibility for producing and supplying HYV quality seeds but its capacity, is extremely insufficient. For instance, in the 1960s BADC was able to meet only 5-6 percent of seed requirements of the country and in 2006-2007 BADC met 15 percent of the total demand of the country.

The National Seed Policy (NSP) adopted in 1993 provided a comprehensive policy and strategy framework as well as directives to increase the production of improved seeds (BADC, 2011). The provisions in the NSP that provided policy directives to manage the seed system include:

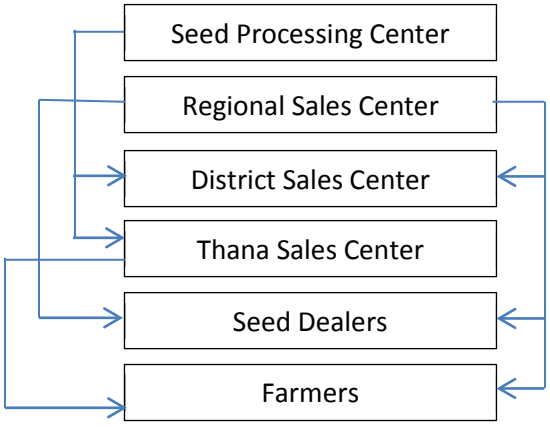
- To increase improved seed production both in the public and private sectors;
- To make best quality seeds available to the farmers on timely basis;
- To strengthen quality control.

The NSP allowed private sector and non-governmental organizations (NGOs) to enter into the seed production and marketing sectors. Since the introduction of the NSP, supply of quality seeds has been increasing steadily. Agricultural Research Institutes, universities and others involved in crop variety development, supply Breeder Seeds to BADC and private sector and NGOs for production of Foundation Seed and Certified Seed (Razzaque 2007). According to Talukder (2011), 14 private sector companies and NGOs have been producing and importing hybrid seeds in Bangladesh. The private sector driven by profit motives is mainly interested to supply and produce hybrid seeds that ensure a higher return on investment for them. In addition, in absence of organized seed producing enterprises within the country many seed traders entered into the market. According to Razzaque (2007) these traders often supply seeds of unknown origin and of unknown quality. Simultaneously multinational companies made easy inroads to the seed business of the country, mostly through importation. These activities are considered threat to plant genetic resources in the Bangladesh agriculture.

BADC has also some capacity to provide services to private sector including seed drying, cleaning, grading, storing, germination, moisture and purity test, and training. In 2008-09, BADC provided training to 258 government participants and 175 participants from private companies and seed dealers. BADC has its own initiatives to improve its supports and it has been providing services to private sector. However, the services are not enough according to the requirement.

In case of the distribution system, there are seed dealers of BADC in every union. The dealers buy seeds from BADC and sell to seed retailers. The retailers then sell it to the farmers. The government has fixed prices for seeds of rice. Seed delivery and marketing system of BADC is presented in Figure- 6.

FIGURE 6. FLOW CHART OF SEED MARKETING



Source: BADC, 2011

Issues Relating to Seed Policy which Need More Attention

Absence of adequate structure and institutional cooperation and quality control

No institutional complementarity exists between public and private agencies. BADC gets subsidy by the government which allows it to provide seeds at a lower cost. However, the private firms do not get such subsidy; therefore they are unable to provide seeds at a lower cost. As the smallholder resource poor farmers have less access to BADC seed they have to depend on private sector and they have to pay high price for purchasing HYV seed.

Unavailability of Seed Bank at village and union level

The absence of seed banks has degraded the conditions of seeds availability. If seed banks were available, the supply process would have been smoother in the senses that by buying seeds at lower prices and store them according to seasonal demand; efficiency would have been assured along with possible lower costs of production. Farmers often buy poor quality seeds from the local market by paying a higher price. Traditionally farmers save their seeds at their farm. However, when a disaster like a flood or a cyclone occurs, farmers lose their seed or become unable to save seed due to loss of harvest. During a natural disaster farmers often need to replant land and if so they have to face further seed crisis. For instance, seed shortage crisis worsened during the 2007 cyclone and flood.

Increasing the use of hybrid rice seeds

BRRI started research on hybrid rice in 1993 with supports from IRRI. Some private seed companies and NGOs imported hybrid seeds in the country in 1995-96 to promote production through demonstration plots. The cultivation of hybrid rice started in Bangladesh in 1998, initially recommended only for Boro season. Gradually more and more land has been brought under hybrid crop production. According to Talukder (2011), 85 hybrid rice varieties have been released in the country until 2010. Of them BRRI developed 4 varieties, private companies developed 2 and the remaining 79 were imported. BRRI, BADC, DAE, BRAC, and some other NGOs have been trying to develop and expand the supply of hybrid seeds in Bangladesh. BRAC has already developed 6 Hybrid rice varieties and 3 Hybrid maize varieties. Trend of Hybrid seed production and import can be seen from Figure-7.

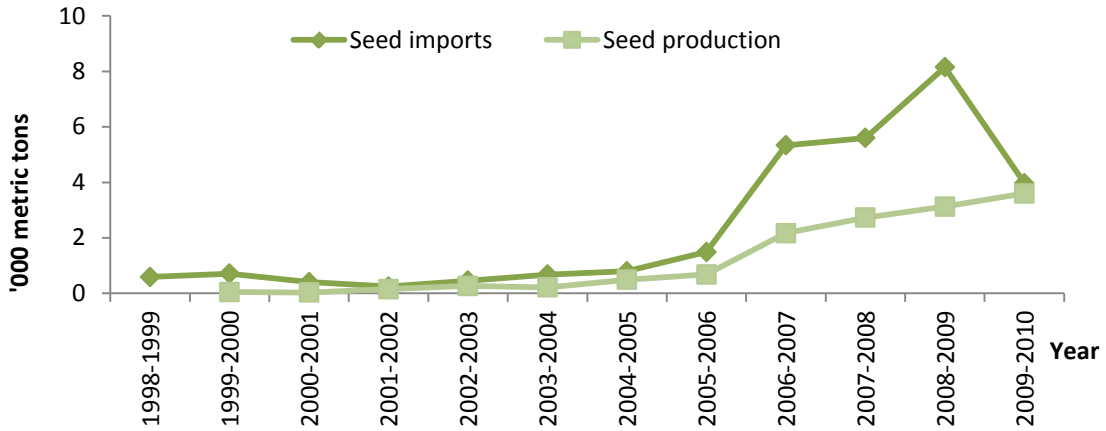
However, farmers in Bangladesh are facing some problems with hybrid seeds. Farmers have to pay very high prices for the hybrid seeds, which they buy from private traders, often 8 times higher than the cost of HYV seeds. They cannot store their own seeds because hybrid seeds do not have regeneration capacity. Poor farmers even have to buy seeds at further higher prices. The New Age of September 12, 2006 reported how farmers were being cheated by hybrid seed traders (Box 1).

BOX 1. FARMERS CHEATED BY HYBRID SEED TRADERS

Most of the imported high yielding varieties of rice and vegetable seeds are substandard with authorities having no measure for ensuring quality, farmers complained. Most of the seed traders in the country import seeds of rice, vegetables, maize, and millet labeled as hybrid and HYV although their seeds are not certified as claimed. An official of Bangladesh Rice Research Institute told the New Age that for hybrid rice seed qualification, the government emphasized on yield rather than quality. He also alleged that some unscrupulous seed traders sold the inbreed varieties like BR-28, BR-29, released by BRRI, as hybrid. Although there is contact between the hybrid rice seed importers and the government for eight years regarding the technology transfer of particular imported seeds, it does not help the agriculture. Over the contact period the traders import the same variety in different names, which goes without action by the government. For vegetable seeds there are provisions of quarantine test at the port and reporting of germination purity at the national seed board, but these are rarely followed. The farmers also cheated by many companies and their agent's market date expired seeds whose germination rate is low. Some private seed traders have no trial field and contact growers to assess the germination rate of the seeds before marketing. Besides, the absence of grow-out test at the government level makes it difficult to find out what is real hybrid seed.

Source: New Age September 12, 2006; adapted from Chowdhury and Uddin; www.unnayan.org

FIGURE 7. HYBRID RICE SEED IMPORTS AND PRODUCTION, 1998-99 TO 2009-10 THE POVERTY-REDUCTION GAP BETWEEN BASELINE GROWTH AND MDG1



Source: Spielman, 2011

Inadequate domestic production

The main detriment of seed supply is the lack of domestic production. Without sufficient domestic production, there is a high dependence on foreign imports hence, high exposure to risks including but not limited to, foreign exchange fluctuations. Until now farmers depend heavily on homegrown seeds other than hybrid seeds. Studies claim that the quality of homegrown seeds is lower than the seeds stored by BADC and others. Farmers are required to access information on the maintenance of seed quality.

Problems faced by the private sectors

Private sector does not produce breeder seeds but either purchase from government sources or imports. Private companies have less seed stock than demand. They lack technical personnel. Support from the government is not adequate. They do not have information to estimate benefits of research and development, which requires significant fixed investment. Most companies have no unit for research and innovation.

Application of Biotechnology in Rice Seed

Although there are controversies, the use of modern biotechnology is widening. Concerns have been expressed about the health, loss of biodiversity and environmental safety. The application of biotechnology in the agriculture sector of Bangladesh is still at its stage of infancy. Some people argue that Bangladesh should not go for the huge investment in biotechnology, because it has risks of health, environment and eco-system and other harmful effects. Others argue that if Bangladesh stops biotechnology from coming into the country just out of emotion then the country will fall behind in the global arena, consequently will fail to pursue its objective of development and particularly food security. Many other optimists support the idea, but they claim that the private sector alongside the public sector must come forward and invest in biotechnology to make any significant impact.

Several studies claimed that benefit of biotechnology far outweighs its cost but there involves risks (Hossain et al. 2004). Countries like Bangladesh still require more rice varieties, which have tolerance for mineral stresses. Many traditional cultivars have acquired these traits through centuries of evolution, but they have very low yields. These traits are known to be regulated by some minor genes. Scientists are using them to develop new varieties but much is necessary to combine them with other traits. Particularly it is necessary to reduce the use of harmful agrochemicals and irrigation as well as to enhance nutritional quality of the products on which most people depend for nutrition. Biotechnology research is necessary in these areas along with socioeconomic research to identify their adoption and related problems.

Response to Climate Change in Seed Production

Agricultural production, particularly rice in Bangladesh is threatened by salinity, flash flood submergence, drought, etc. due to global climate change. About one million hectares in coastal districts of Bangladesh are prone to different levels of salinity. Further, a vast area remains fallow in dry season (*Boro)* due to the prevailing saline soil and lack of irrigation water including salt tolerant rice varieties. In response to this problem, BRRI has developed salt tolerant rice varieties like BR23, Brridhan 40 and Brridhan 41 for *Aman* season having characteristics of high yielding, photoperiod sensitive, lodging tolerant and with 15-25 days shorter growth duration than the traditional local varieties.

Development of Brridhan 47 for irrigated ecosystem is a major breakthrough in breeding for salt tolerant rice in Bangladesh. The yield potential of the variety ranged from 5.4 to 8.3 tons per hectare in saline prone areas. National Seed Board of Bangladesh also approved the recommendation of technical committee to release Brridhan 53 and Brridhan 54 salt tolerant varieties for T. *Aman* season. These two varieties are specially recommended for brackish shrimp field of coastal saline prone areas of Bangladesh but can also be cultivated at normal rainfed condition.

Flash floods regularly affect rainfed lowland rice ecosystems in lowland where flood water remains for around two weeks in many parts of the country. In Bangladesh more than 2 million hectares rice lands are unfavorably affected by excess water and periodically suffer from flash floods and complete submergence for around 2 weeks resulting crop damage. Recently, BRRI in collaboration with IRRI released two flash flood tolerant varieties for T. *Aman* season which are Brridhan 51 and Brridhan 52.

Again, more than 2.0 million hectares of cropped land are affected by drought during both dry (upland) and wet (T. *Aman*) seasons. In this context, 4 upland rice varieties (BR21, BR24, Brridhan42, Brridhan43) for moderately rainfall areas were released by BRRI with moderately high yield potential. Breeding efforts are being continued to develop drought tolerant varieties for upland drought prone ecosystem.

Role of Women in Seed Processing

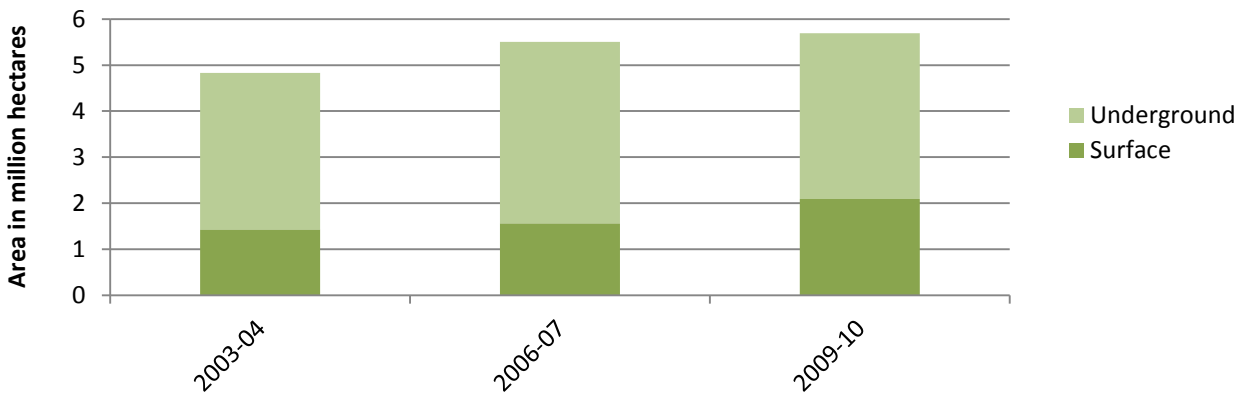
Women's role in agriculture is under represented because women in Bangladesh traditionally do not involve in the field work to a greater extent, though they often perform field work invisibly. However, post-harvest activities are considered women's domain. Seed testing, germination, seed selection, and storage are extensively handled by women in many areas. With the initiatives of Poverty Alleviation Thorough Rice Research Assistance (PETRRA) project of IRRI in collaboration with BRRI, some seed villages have been emerged in Bangladesh, particularly in Bogra district in Bangladesh where women are heavily involved in seed processing and preserving using improved techniques. However, women are dependent on male members in the family to get access to seeds from market and training related to input storage and quality control.

Irrigation

Overview

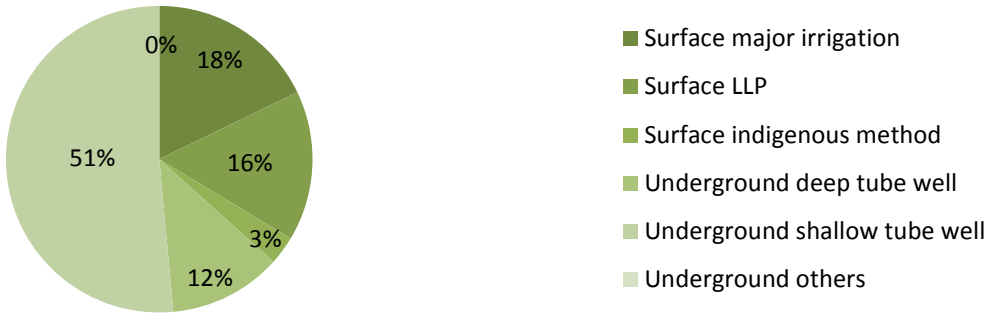
Irrigation system contributed substantially to increased production for ever increasing population of the world. Seeds, fertilizers, irrigation and pesticides are highly complementary inputs (Norton et al. 2006). New varieties of rice, wheat, maize etc. are more responsive to fertilizer, water and pesticides. The Green Revolution invented new seeds causing increased use of water. Increased use of irrigation has enabled double or triple cropping cultivation of land and made huge contribution to productivity. However, along with positive contributions of irrigation and water to agricultural productivity there are negative contributions in terms of mismanagement, overuse, depletion of groundwater, damage of ecosystem, and health hazard like arsenic contamination, which can be viewed threats to sustain productivity. In Bangladesh, irrigation is dominated by underground source of irrigation compared to surface water irrigation (Figure- 8). However, at the begging of irrigation development in Bangladesh surface water irrigation was dominant (Jaim, 1993). Again, among the underground irrigation technologies, Shallow Tubewell (STW) dominates which covered about 51 percent irrigated area in 2009-10 (Figure- 9). This section examines the irrigation system in Bangladesh to identify policy options for its sustainable use.

FIGURE 8. SOURCES OF IRRIGATION BY BROAD CATEGORIES: 2003-04 TO 2009-10



Source: Bangladesh Economic Review, 2010

FIGURE 9. SHARE OF IRRIGATES AREA BY DIFFERENT IRRIGATION METHODS: 2009-10



Source: Bangladesh Economic Review, 2010

Irrigation System in Bangladesh

The adoption of green revolution technology in Bangladesh increased the use of irrigation technologies along with other modern inputs. Initially large irrigation systems were established in South-Western, Northern and North-Eastern Bangladesh (for example the Ganges-Kobadak Irrigation Project). Minor irrigation was spread gradually all over the country. Government's Thana Irrigation Project (TIP) and BADC's own program initially supported surface water Low Lift Pumps (LLPs) and ground water Deep Tube Wells (DTWs). The use of ground water shallow tube wells (STWs) was then spread across the country in irrigated areas. DTWs and LLPs were rented seasonally to cooperatives and a variety of informal farmers' groups with relatively low rental charges, involving substantial subsidy. DTWs were installed in response to demands by farmers groups after site inspection by BADC, and rented on an annual basis to the group. STWs were sold to private individuals or groups at prices which contained virtually no subsidy but they were provided with subsidized credit from nationalized banks subject to controls on their installation at a site sanctioned by BADC. In the first five-year plan (1973-1977) after the independence of the country, the state heavily invested in irrigation facility in order to increase the production of modern variety of rice. In the late 1970s and early 1980s the *Boro* rice production grew considerably due to various projects to support sales of STW and to a lesser extent DTW (Palmer-Jones 1992).

In fact, BADC initiated minor irrigation development in the 1960s, before the independence of the country in 1971. During the early years of Bangladesh BADC selected technologies, imported standardized equipment, and regulated its location in the fields. The operation of all types of irrigation equipment including private STWs was subject to regulatory control by BADC. Thus the BADC handled the procurement, marketing and distribution of irrigation equipment in Bangladesh until the extensive reforms in agricultural input sector took place.

TABLE- 2 POLICIES, REFORMS AND REGULATORY SITUATION, AND IMPACT REGARDING IRRIGATION SYSTEM AND TECHNOLOGY IN BANGLADESH

Reference year	Policies/reforms/regulation	Impact
1972-1977	Publicly owned DTWs and LLPs, rented out by BADC to individual farmers or groups. Rental charges were low (subsidized); STWs were sold without subsidy (Hossain 1988); Subsidized credit was given to rich persons to buy STWs (Palmer-Jones 1992); the operation of all types of irrigation equipment was subject to regulatory control by BADC.	Use of irrigation expanded; a huge financial burden of the government; often wealthy farmers and individuals enjoyed the benefit of government subsidy.
1978-1984	Reform begun in 1978-79; private sector was allowed to import and distribute STWs subject to regulations related to brands, horse power, water lifting capacity, fuel type etc.; subsidy on DTWs and LLPs was reduced;	By 1983, 43% of operating DTWs, 48-56% of the LLPs and almost 100% of STWs were sold to private sector (individuals or groups); The coverage of irrigation increased from 1569.1 ha in 1979-80 to 4725.63 ha in 2004-05.
1985-1987	Government established a workable foreign exchange market and ended many non-tariff barriers (Gisselquist et al. 2002);	During the 1985–2000 period, total area under irrigation more than doubled: from 1.77 million ha in 1984/85 to 4.03 million ha in 1999/2000
1988-1989	Unrestricted private imports were allowed and duties on imported machinery were removed; regulations on standardization of irrigation equipment were totally withdrawn (compulsory registration was suppressed); tariff cuts on diesel engines from irrigation from 15% to 0% (Gisselquest and Grether 2000)	From 1988 to 1996 operation of small pumps increased to 170%; 16% of gross cropped area were brought under new irrigation; retail price of diesel engines for irrigation fell by more than 50%; STWs occupies about 59% of total area irrigated as against 23% in 1986-87 (Chowdhury and Uddin undated)
2007-2009	Direct subsidy for irrigation on per acre of irrigated land; reduced the price of diesel during the Boro season	Reduced cost of production of Boro paddy.
2009	Subsidy for diesel operated irrigation pumps / engines were given. Farmers having less than 2 acres of land (irrespective of whether they were tubewell / pump owners or purchased irrigation water) were paid Taka 800 subsidy per person.	Small farmers were benefitted as a result of reduced irrigation cost.
2010 and at present	No subsidy on diesel or to the individual farmers for irrigation was given.	Irrigation cost increased, affected mostly the water purchasers.

Source: Hossain, 1988; Palmer-Jones, 1992; Gisselquest and Grether, 2000; Jaim (Field survey, 2012)

Public sector engagement was a huge financial burden of the government. Regarding the STWs, though BADC regulated the sales, private individuals, with sufficient wealth and social influence bought STWs, usually enjoying the benefit of subsidized credit from state-owned banks. So the benefits were reaped heavily by the wealthy individuals, often by absentee land owners.

In the liberalization era under the aegis of the World Bank and the IMF that started in the 1980s, the irrigation sector has been reformed in stages. Table- 4 presents some important reforms causing impacts on the expansion of irrigation and irrigated areas. The reforms, begun in 1978-79, allowed the private sector to import and distribute STWs subject to 'standardization' requirements mainly on engine configuration i.e. some technicality like brands, horse powers, water lifting capacity, used fuel type and so on. The policy of increasing rental charges on DTWs and LLPs, however, was pursued in parallel with that of selling these to cooperatives and private individuals, with assisted access to cheap institutional credit. By 1983, 43 percent of operating DTWs and 48-56 percent of the LLPs were transferred to the private individuals or groups, while STWs were almost entirely privately owned. Groups were formed through unions of farmers and the ownerships of DTWs and LLPs were left to these groups as a whole.

Privatization of the import of irrigation equipment began in 1986, accompanied by the lifting of restrictions on their makes and models (brands), initiating the dismantling of the standardization requirements. The next step in the deregulation process came about in 1988, when unrestricted private imports were allowed and duties on imported machinery were removed. Furthermore, regulations on standardization of irrigation equipment were totally withdrawn. These changes were accompanied by the complete elimination of subsidy on minor irrigation equipment.

The activities of the private organizations along with government activities enabled farmers to produce their crops with appreciable success. However, the success disproportionately benefitted the rich farmers. Prices paid by them are often below the marginal value product of water as an input but poor farmers are unable to get access due to cash constraint and other problems. Small irrigation equipment was also bought under liberalization. The poor and marginal farmers have lost access to this service due to steep prices. The farmers who linger at the bottom do not have sufficient access to irrigation along with other inputs. The distribution of benefits from irrigation development is thus largely skewed and unequal.

At the same time, the huge expansion of ground water use created environmental threat. There is lack of research identifying social costs and benefits of water use as an input. Though food grain production in Bangladesh has more than trebled over the last 30-40 years; soil quality has been degraded and groundwater resources depleted. Inland lakes and waterways have been exploited unsustainably, to the increasing distress of over ten million poor fisher-folk whose catch provides vital protein.

Constraints to Farmers

Irrigation reforms resulted in an increased use of irrigation. Prior to implementation of privatization and liberalization policies in 1988, irrigation market was largely controlled by commercial class of people. Big land owners privately owned STWs and DTWs sold irrigation services to small farmers at exorbitant prices. The owners of STWs and DTWs were known as water lords. Studies claimed that irrigation market was controlled by a small number of influential water lords. This caused inefficiency in the market and poor farmers had to pay high prices due to inefficiency. With the change in irrigation policies, the private sector were allowed to import small sized irrigation equipment, particularly STWs from China. The price of STW, LLP, etc. became much lower compared to pre-privatization period and medium farmers, even the small farmers were in a position to afford to buy the irrigation equipment. Thus, they became owners of STWs instead of water purchasers. With small engines and with small sized command area, particularly for STWs problems of water distribution and conflicts of tube well owners and water purchasing farmers much reduced compared to previous situation covering large command area dealing with large number of farmers. However, problems still exist with large number of small/marginal farmers including tenant farmers who are water purchasers. Rigorous analysis is necessary to investigate present market structure and access to irrigation by the marginal and tenant farmers.

Under the current high irrigation price regime, poor farmers are unable to buy irrigation services. This is a threat to sustainable production as the marginal / poor farmers represent about 88 percent of the farm households. An ADB supported study in Bangladesh confirmed that, the pro-poor impact of freeing the market in small pumps reduced the vulnerability of smallholders to “water lords” and the emergence of a competitive water market with excellent water service even to the poorest farmers. However current situation is not favorable for smallholder farmers.

Research directions

Up to date research is inadequate on the current constraints on irrigation and the resulting consequences on farmer income and farm productivity. Little empirical knowledge exists on the specific poverty, irrigation inequality and productivity nexus. Lack of analysis on productivity impact pathways of policy and institutional interventions exists in the irrigation sector. Attempts to target the poor have met with limited success. Rigorous analysis of poverty, water scarcity and low productivity in low performing irrigation systems and their relationship with the policy and institutional environment is therefore needed to develop effective poverty reduction strategies. Attention must be paid to broader analysis of irrigation performance in the context of scarcity and competing uses of water basins and to finding ways to increase the productivity of water used in agriculture. Other broader issues such as institutional reforms at the system and river basin levels and the understanding the irrigation-poverty nexus must be addressed urgently. Poverty and gender in irrigated areas is currently a subject of special research.

RESEARCH, DEVELOPMENT AND INNOVATION

Overview

Increasing production requires technological innovation that comprises ‘invention’ and ‘adoption’. Neoclassical growth theories assumed that technological invention occurs automatically. New theories demonstrated that technology is induced by market forces, which direct research and investment for new invention of technology (Hayami and Ruttan 1985). This induced innovation theory helps explain the mechanism by which a society chooses an optimal path of technical and institutional change in agriculture (Norton et al. 2006). However markets do not function well due to multifarious reasons.

Transaction costs, institutional barriers, lack of information, poverty etc. restrict farmers to respond to market forces. The government is responsible to correct market failure. In many cases the public sector fails to do the right things.

Seed, fertilizer and irrigation technologies are technical know-how resulting from long standing research. Effectiveness of research, extension and innovation is a major determinant of growth in agricultural production. Consistence evidence is available that the return to agricultural research is high (ibid, chapter 12). Agricultural productivity per worker rose substantially in many countries due to new technologies. Research can be used to solve many agriculture related problems. Research can be used not only to improve productivity but also to reduce fluctuations in food supply, prices, and income and thereby ensure food security. In spite of this, the developing countries have inadequate budget to spend on research and innovation. Pressures are frequent to reduce public funding for research. Research is necessary to develop more responsive variety of crop so that output produced per kilogram of fertilizer increases. Private companies need to come forward by setting more specific rules and guidelines to finance agricultural research. Government should create enabling environment so that private companies systematize product development process and contribute more to research and innovation.

Research and Development, and Innovation System: Private and Public

Between 1976 and 1992, the World Bank committed more than $5 billion to agricultural research and extension around the world; in the mid-1990s, annual support levels totalled more than $400 million (Purcell and Anderson 1997). Investments such as these have yielded high returns and important impacts on poverty in the past (Fan, Hazell, and Thorat 2000; Fan, Zhang, and Zhang 2002). Gradually the support was curtailed due to the faults in the country level programs and policies for poverty reduction, though this type of blames is not often entirely justified.

Bangladesh has made notable success in attaining rice production. The growth of rice production has surpassed the growth of population. This was achieved through intensive use of modern technology and under the adverse condition of falling real rice price, sharply rising agricultural wage rate and declining availability of land for cultivation. The major sources of growth were inputs relating to seed-fertilizer-irrigation technology and their productivity. This is due to the innovative rice varieties resulting from research undertaken by international and national organizations.

The International Rice Research Institute (IRRI) was established in 1960 as one of a set of international agricultural research centers that are coordinated through the Consultative Group of International Agricultural Research (CGIAR). IRRI released IR-8, which produced more grain and less straw but responded to high rates of fertilizer and water application. Subsequent research gradually focused on improving grain quality, incorporating disease and insect resistance, developing varieties for drier upland areas, and developing varieties for deep water and submerged conditions. Besides these, current research is focusing on adding micro-nutrients in rice grain through bio-fortification to address micro-nutrient deficiency particularly for women and children.

In Bangladesh different research institutes, public and limited private universities and development organizations including NGOs carry out agricultural research. Bangladesh has ten public research institutes under the National Agricultural Research System (NARS). The NARS system is linked to the Ministries of Agriculture, Fisheries and Livestock, Environment and Forests, and Commerce. All institutes except Bangladesh Forest Research Institute now operate under Acts/Ordinances that give them limited autonomy. These institutes highly concentrated on technical research, such as plant breeding, soil analysis, seed production etc. (Quasem and Yasmin 2010). In terms of quantity, research is substantial research but there is lack of research in priority areas like socio-economics in agriculture. It is always necessary to update research on constraints to technology adoption, monitoring and evaluation of research, constraints to marketing of inputs and outputs, and new opportunities arising for smallholder farmers due to changing circumstances. However, good quality research is extremely limited in the areas of regional rice production, marketed surplus, private trading and market integration, alternatives to rice consumption, export potential of fine rice etc. (Quasem and Yasmin 2010).

Comprehensive information on agricultural research and development (R&D) conducted by the private sector is limited. An in-depth survey in 2009-11 was conducted by ASTI and partners on the private sector's role in research and innovation in Bangladesh, India, Kenya, Pakistan, Senegal, South Africa, Tanzania, and Zambia. Results are yet to be made available.

Bangladesh has been gradually easing the regulations that are not conducive to private sectors involving in agricultural research, development and innovation. USAID supported Agro-based and Technology Development Projects I and II during 1996-2005 may be the pioneer attempt to expand private agricultural innovation. The World Bank supported the Krishi

Gobeshona Foundation (KGF) to fund private and public agricultural research. A survey of 51 private organizations (49 companies and 2 NGOs) in Bangladesh from June to October 2009 was carried out by Rashid et al (2011). According to this survey, private agricultural R&D has been expanding rapidly, but the claim is based on the survey of specific organizations. Impartial analysis is necessary to identify the quantity of these innovations as well as the impact, specifically on smallholder farming.

Importation and marketing of some items are regulated such as seeds of rice, wheat, potatoes, jute and sugarcane. From the government register, Rashid et al. (2011) noted that during 2000-2010, 33 private companies and NGOs registered 76 rice hybrids. These organizations did not register any other regulated items like wheat, jute and sugarcane. A survey of seed stores throughout Bangladesh found 70 maize hybrids, mostly came from China, India and Thailand; only 1 or 2 were introduced through local breeding. The impact of this unregulated imports and marketing should be identified through impartial research.

Some Issues Regarding Research and Innovation

Government-based agricultural research in Bangladesh is coordinated by the Bangladesh Agricultural Research Council (BARC). BARC, however, has no control over the allocation of the financial resources. In 2002, BARC and its 10 affiliated research institutes accounted for about three-quarters of the country's agricultural research expenditure. Agricultural research has depended on donor financing, particularly in terms of World Bank loans, which facilitated considerable investments in infrastructure and equipment. Bangladesh's agricultural research capacity has deteriorated in terms of researcher numbers as a result of the brain drain of the qualified and experienced researchers. The private sector has minimal input into agricultural R&D in Bangladesh, though greater involvement is anticipated in the future.

AGRICULTURAL EXTENSION

Evolution of Extension Systems in Bangladesh

Agricultural extension has a long history of evolution worldwide. Agricultural extension services include transferring knowledge to farmers, advising and educating farmers in their decision making, enabling farmers to clarify their own goals and possibilities, and stimulating desirable agricultural developments. It is widely accepted that extension services are an important element within the array of market and nonmarket entities and agents that provide human capital-enhancing inputs, as well as flows of information that can improve farmers' and other rural peoples' welfare. Historically, agricultural service delivery in developing countries started with production-oriented limited extension services for export crops. The attention was diverted in the fifties to food production and improved farming techniques (Anandajayasekeram et al. 2008). In the 1960s US-led 'technology transfer model' employed a large number of extension agents to provide extension services. Since then, with the rise in the demand for agricultural services, many variants of approaches, models and methods have been evolved to connect researchers, extension agents, producers and consumers (Garforth 1982; Feder, Just and Zilberman 1986; Anderson and Feder 2007). The World Bank sponsored Training and Visit (T&V) extension model, Farmers Field Schools (FFS) and fee-for-services are the most common broad approaches. In the T&V and FFS systems, extension workers passed information to selected contact farmers who shared information with other farmers (Anderson and Feder 2007). The T&V system was introduced in Bangladesh in 1977. The system was questioned with respect to poor linkages with research, incompetent staffs, dissemination of inappropriate technologies and information, among others.

FAO's rice Integrated Pest Management program, funded by UNDP, introduced Farmer Field Schools (FFS) in Bangladesh in the early 1990s. Since 1997 DANIDA has been supporting the up-scaling and further development of FFS approach, initially through the Strengthening Plant Protection Services projects (SPPS-1 and SPPS-2, from 1997-2006) and then through its Agricultural Sector Program Support phase 2 (ASPS-2). FFS is a season-long training activity that takes place in the field.

FFS is implemented under the Agricultural Extension Component (AEC) of the Department of Agricultural Extension (DAE) under the Ministry of Agriculture (MOA). DAE is one of the core departments of the government responsible to provide agricultural extension services to all categories of farmers. DAE has been involved in running Farmer Field Schools for more than 20 years with several thousands of extension officers at field level. It is a comprehensive training on integrated crop management (ICM), which uses various innovative training materials. The approach is currently one of the forefront extension- related activities sponsored by FAO, and the principles and methodology of the approach are being replicated by other technical services such as Irrigation and Water Use and Forestry. Quizon, Feder and Murgai (2000) provide an interesting perspective on FFS as an alternative learning or problem-solving approach. They view FFS not as an extension approach for

disseminating information, but as an empowerment and citizenship opportunity. At the same time, they raise FFS cost issues and their relevance to the sustainability of this approach. In addition to cost issue, linkages of research and extension are reported to be weak.

Agricultural Extension Services: access to farmers and improvements in farm productivity

Extension services provided in the developing countries are extremely inadequate. In Bangladesh, government recognizes that agriculture is the key driver of development. The DAE carries its activities in the field level with the help of its different wings. The main objectives of DAE include motivating and helping farmers adopt improved production practices to increase their productivity, providing farmers with the latest research results and farm techniques so that using such techniques farmers improve their socioeconomic condition, providing farmers with training on improves practices, leadership and organizing group, etc.

First national agricultural extension policy was formulated in 1996 (MOA1996) followed by its plan of action 1999-2002 (MOA 1999), which recognized that it is necessary to develop an extension approach to work together with farmers to adequately address their problems. The DAE 1999-2002 was a strategic plan with large number objectives, appeared too ambitious given the limitation of resources and capacity. Some achievements include formulation of checklists for supervision, production of ten thousand posters for extension development, 64 district officers were given training, Integrated Pest Management was promoted through the use of FFS, etc. The DAE has developed Memorandum of Understanding for partnership with other GOs as well as with NGOs. Seminars and workshops on gender sensitization were held at national and regional levels. Eco-team modules were developed with Upazila level staff. A revised training approach and DAE training policy were developed in 2001 to bring all training activities of all projects under a common management system. In addition, DAE attempted to improve information and communication system by providing training to its Block Supervisors, creating opportunities of higher studies for mid-level officers and developing computer centers and email facilities, etc. However, the small farmers who are the main actors in national food production still confront many inherent problems which need to be addressed. Though the responsibility of the DAE is to provide extension services to all categories of farmers, small and marginal farmers often receive services disproportionately. Commitment and accountability were not enough, monitoring was weak, and the implementation of the plan was extremely slow due to lack of resources and capacity. Farmers who live in remote areas remain beyond the reach of extension services.

Failing to achieve the objectives of the plan 1999-2002, DAE formulated the Strategic Plan 2002-2006 to achieve five specific objectives such as:

- Increase agricultural productivity,
- Provide pro-poor services,
- Strengthen partnership and links with local government,
- Develop DAE as an effective institution for providing quality and quantity services, and
- Develop performance measurement

There is not sufficient information within DAE of how many farmers are actually reached and serviced by this organization. Large scale farmers perceive DAE as generally not competent enough to provide advisory services necessary for commercialization. On the other hand, adoption of available technologies has not reached expected levels within the smallholdings, which have very low productivity.

Public research cum extension organizations, donor supported rural development program, NGOs, private agro-chemical input suppliers, public community development and agricultural extension service providers, etc. are also involved in providing extension services. The services provided by these stakeholders are not enough in the context of farmers' benefit. Especially innovations are still not suitable to reach to extension services to remote areas such as the area of *Char, Haor* and river bank.

Strengthening Research Extension Linkages

The lack of working relationship between national agricultural research and extension organizations, and with different categories of farmers and farm organizations is well known worldwide and Bangladesh is not an exception. Generally research and extension organizations compete over the same scarce government resources. National Agricultural Technol-

ogy Project (NATP) in Bangladesh has been supporting agricultural extension and targeted Farmer-Research-Extension linkage activities. The activities are:

- Early involvement of researchers in extension planning and work on demand-based on-farm technology validation;
- Demonstrations, field days, fair, workshops and farmer exchange visit including increased use of communication technologies for training and dissemination extension information; and
- Establishment of Farm Information and Advisory Center (FIAC) at Union level to promote farmer to farmer information exchange. In this endeavor, commendable achievements have been made.

In this project, BARI and BRRI provide training to DAE personnel. Both the research organizations has also been involved in field activities by providing critical inputs (seed, new varieties, foundation seeds, etc.) for demonstrations and technical cooperation in implementing on-farm demonstrations and validation trials. During 2008-09, a good number of farmers and field level extension personnel have visited different research stations through organized Motivational Tours. Research-Extension-Farmer linkage is maintained through National Agricultural Technology Coordination Committee (NATCC) at National level and Agricultural Technical Committee (ATC) at regional level. These committees will be strengthened through NATP project. This is early to evaluate the project impact on research technology linkage.

Policy Options to Improve the Ability of Resource Poor Farmers

The extent of support services for farmers in Bangladesh has proved efficacious and development of the agriculture sector is now considered satisfactory in the national context. Food security can be ensured in the country with appropriate policy and actions but the small farmers who are the main actors in national food production still confront many inherent problems which need to be addressed.

Mobile phone supported technology should be developed to inform the farmers of remote areas with new methods and practices that could enhance the productivity. There are examples in India such as the Rural e-services Project (Xiaolan and Akter 2011). In this project a mobile phone enhanced technology was invented to link agricultural experts with remote farmers through mobile phone and village workers, who otherwise would remain unemployed. This type of innovative technology could simultaneously improve farm productivity and increase off-farm employment.

There is insufficient information on the number of farmers who are actually reached and serviced by the DAE. Large scale farmers perceive the DAE as generally not competent enough to provide advisory services necessary for commercialization. On the other hand, adoption of available technologies has not reached expected levels within the smallholdings, which have very low productivity.

Public research cum extension organizations, donor supported rural development program, NGOs, private agrochemical input suppliers, public community development and agricultural extension service providers, etc. are also involved in providing extension services. The services provided by these stakeholders are not enough in the context of farmers' benefit. Especially innovations are still not suitable to reach the extension services to remote areas such as the area of *Char*, *Haor*, river bank and coastal areas. Use of mobile phone supported technology may be very much appropriate in this case; however, this needs further verification.

INPUT MARKETS AND TRADE

Overview

Input markets in Bangladesh followed a path of evolutionary reform since independence of the country in 1971. BADC had the monopoly of market structure for all agricultural inputs. Input markets have been gradually liberalized with significant restrictions. The lack of easily accessible markets and collusion by the traders pose significant constraints in both agricultural input and output markets. Lack of market information and infrastructure, the poor law and order situation, the existence of syndicates, and collection of illegal tolls further aggravate the situation.

Liberalization of Input Markets

Liberalization of input markets in Bangladesh started in the early 1980s. The state has gradually withdrawn subsidy and support that benefitted the wealthier farmers more than the poor farmers who have less access to market based reforms. Landless and marginal farmers are compelled to pay higher prices for agricultural inputs. Due to this reason the contribution

of the sector has reduced. Recently growth of the sector appears satisfactory due to increased investment in agriculture. Allocation in budget for public expenditure for agriculture had increased from Tk. 104300 million in 2008-09 to Tk. 130840 million in 2010-11 which however, declined to Tk. 125280 million in 2011-12 (Hossain and Narayan, 2011).

Fertilizer Market

The methods used in the fertilizer marketing in Bangladesh have varied in the past 50 years or so. From the 1950s to the early 1980s, under the Old Marketing System (OMS) the BADC controlled all aspects of marketing and distribution of fertilizer. All marketing functions along with price fixation and storage were carried out by the BADC. The problems of the system include uncertainty in the supply, insufficient storage capacity, and absence of incentives for farmers and dealers and others that cause inefficiency in the system. In the late 1970s, the New Marketing System was formed to liberalize the system. This consisted of privatizing and deregulation of the fertilizer industry and making it a competitive market. This would ensure efficient allocation of fertilizer and also its timely availability. The two main advantages were, before the government had to keep huge amounts of stock in its warehouses which increased the costs, but because a competitive market responds quickly to market signals, this problem was minimized. Also, the scope for abnormal profits in a competitive market is not there, so prices were lower, so fertilizer could be marketed to more farmers. The NMS had profound effect on the marketing system of Bangladesh. For example, market forces have pulled the prices down significantly because the distributers have had to economize operations and reduce profit margins. Also, the availability of fertilizer has increased with falling prices which has extended the market and finally, there have been huge savings to the economy; in 1989-90.

By the 1990s the NMS was in full swing and the control that BADC had before was almost gone and the privatization and deregulation of the fertilizer industry was almost complete. There are also some disadvantages of the NMS system mainly caused by privatization such as profiteering during the *Boro* season; the prices are hiked by the traders to increase their profits. Another problem is adulteration by the distributers to increase profits (Jaim 2001). The quality of many fertilizers has been found to be low with up to 80 percent adulteration in some cases.

The recent policy environment that has developed due to the problems with the new marketing system such as, the prices of urea is still subsidized by the government due to a crisis in 1995. Also, there are other policy issues which are facing Bangladesh right now. For example, there are coordination problems caused by the lack of coordination between fertilizer factory owners, dealers and importers which causes inefficiencies. Further, because urea prices are regulated and subsidized, there are no market signals to indicate short supply. Hence, the urea crisis of 1995 may be repeated.

The urea crisis of 1995 was severe. During this time, the demand for urea far exceeded the available supply due to various problems in the marketing, distribution and storage of urea. Moreover, there is an annual crisis for fertilizer during the *Boro* season. The main reason is the lack of co-ordination between the different agencies and lack of proper monitoring.

This and other problems have meant that the distribution network has recently been overhauled to improve the marketing of fertilizer. The government has recently (2008-2009) set that there should be at least one dealer for each union. This has made the union a focal point for fertilizer distribution. Also, restriction on dealerships in districts, introduction of ID cards has all been done to strengthen the marketing and distribution network of fertilizer. The dealers can acquire fertilizer from either BCIC gates or from buffer stock centers.

It appears that fertilizer marketing and distribution system in Bangladesh is unsettled; monopoly public sector as well as attempts to privatize the sector failed to bring the desired outcome. The privatized fertilizer market was still in its infancy when policy was redirected towards strengthening re-introduction of fertilizer subsidy. Whether privatization or regulations, the system needs nurturing from the government to become efficient and fulfill its purpose. This is of the utmost importance to Bangladesh because other thrust sectors as well as the overall economy and GDP depend heavily on agriculture. The marketing system in the fertilizer industry is still fraught with problems and hence a lot of farmers are still deprived of fertilizer during the harvest season. Initiatives should be taken to overhaul the structure and operations of the marketing of fertilizer in order to ensure farmers get adequate supply during plantation / seeding period. This will ensure the proper growth of the agricultural sector and help realize its full potential. The government needs to continue subsidize the poor farmers as they are unable to purchase adequate quantity on time but with caution. Appropriate targeting is very important to save public resource and to reach the right farmers with subsidy.

The marketing system in the fertilizer industry has been fraught with problems and hence a lot of farmers are still deprived of fertilizer when necessary. Initiatives should be taken to overhaul the structure and operations of the marketing of

fertilizer in order to ensure farmers get adequate supply when transplanting season comes. This will ensure the proper growth of the agricultural sector and help realize its full potential.

Seed Market

Under the seed marketing division of BADC, there are 22 regional, 42 district and 36 Thana sales centers all over the country. They are distributed to districts and Thana sales center according to distribution program. In the private sector, seeds are similarly distributed. About 95 percent of the rice hybrid seeds provided by private sector are imported. These seeds are costlier than HYV seeds.

Irrigation market

Irrigation availability and access are prerequisites for adopting new technology and therefore for enhancing productivity in agriculture. Accessibility depends on market structure. As in many other developing countries, Bangladesh has no well-functioning market for irrigation services. Irrigation services market is often called water market. During the pre-liberalization period BADC had the monopoly power to control water market. BADC followed a system of renting out publicly owned DTWs and LLPs to cooperatives and a variety of farmer groups. The rental charge was extremely low covering only 10-15 percent of the cost of the program (GOB 1982). STWs were sold to private sector.

Market-based reform of irrigation equipment and services started in the late 1970s along with other inputs. The market was gradually opened up causing a shift from a single-channel government controlled system to multi-channel market based system with some form of regulations. Activities for opening the door towards competitive market structure include gradual reduction of subsidies, increase of rental charges of DTWs and STWs along with selling these irrigation systems to cooperatives and private individuals wherever possible. By 1983, 43 percent of operating DTWs and 48-56 percent of the LLPs were transferred to private individuals or groups. As unrestricted private imports of irrigation machineries and equipment were allowed in 1988. As a result, farmers increasingly shifted to competing private traders who imported a wide range of low-costly diesel engines from China. This results in a sharp decrease in equipment prices and hence increases the sale and use of imported machinery (Gisselquist and Greather 2000). By the end of the 1980s, cost of investment in minor irrigation equipment became less than half what it had been in 1981-82. From 1988 to 1996 minor irrigation expanded at record rates; for example, the number of small power pumps lifting ground and surface water for irrigation increased by 170 percent. Competitive markets developed for smaller and smaller irrigation equipment. NGOs also developed some innovative irrigation schemes.

As usual, this market based system put the small farmers in disadvantage position, because they are unable to compete with large farmers due to socio-economic constraints such as lack of access to credit, high transaction costs, lack of information, low social status and other cultural problems. Opening up the market without making any provision for the marginal and small farmers made them to pay exorbitant prices. Studies on market structure are inadequate (Palmer-Jones 2001). Whatever empirical evidences available give us an idea that the markets are controlled by rural elites and large land owners. This type of markets are often analyzed in the framework of monopoly or oligopoly of water-lords or in the framework of contestable markets, where freedoms to entry is high and costs to exit is low. Minor irrigation market may be more competitive than other irrigations. Still poor farmers cannot get access due to multifarious constraints such as farm size and land tenure systems as well as physical conditions such as agro-ecological characteristics, groundwater aquifers, expansion of equipment market at the local level, growth of physical infrastructure and provision of electricity and institutional factors like credit market failure. Mandal (2000) noted that market for minor irrigation is well spread in some regions. A new form of partnership arrangement has emerged for taking up irrigation as a business enterprise where choice of partnership appears competitive but not perfect due to many socio-economic reasons. The major reasons for choosing partners include mobilization of enough capital for purchase and operation of irrigation machines, meeting kinship or social obligation, enlarging and protecting a viable command area with partners' land and social supports, and acquiring adequate financial and moral strengths to do water selling business without threat of encroachment from the competing pumps, etc. This type of problems makes poor farmers' access difficult.

It is often claimed that free water market resulted not only in increased competition but also reduced the vulnerability of small holder farmers to water lords. Particularly, the long term benefits are reaped by the poor through multiplier effects. Poor farmers are getting cheaper irrigation and hence are capable to buy more and produce more crops. On the other hand, there are evidences that water market controlling by rich merchant class, though increased the irrigation coverage but poor farmers became marginalized and paying exorbitant prices. It is necessary to investigate which of the claims mostly prevails, whether water lords still exploiting the poor, etc. There is a serious lack of rigorous analysis. Furthermore, debate is still

continuing without rigorous analysis on the type of market structure. It is necessary to identify whether the market is monopoly of water lords or oligopoly or another type to draw better policy conclusions.

Market Regulations

Regulations that are market friendly are necessary but regulatory barrier is the most important obstacle to enhance productivity. Regulations impede the transfer of technologies through private trade in seeds and agricultural inputs and so obstruct productivity (Gisselquist and Grether 2000). Regulations may apply for in-country transfer and international transfer of technologies. Agriculture has become a high technology field, and in industrial countries hybrid seeds boosted potential yield manifold. Leading countries continually share, borrow and build on research from other countries. Regulations in developing countries are often not market-friendly and are problematic for seeds and other inputs. Bangladesh has been gradually easing regulations for trading agricultural inputs. Research is inadequate to identify which of them are benefitting the small, marginal and poor farmers. Regulations often benefit the large farmers and traders.

Input-Output Market and Farmers' Profitability from Rice

Seed-fertilizer-irrigation intensive technology for producing modern varieties of rice has increased cost of production, particularly for HYV *Boro* rice which is now the main rice crop in Bangladesh. Again proportion of cash expenditure compared to non-cash expenditure has also increased. On the other hand, price of rice in general has decreased in real terms over the years except in some years. As a result, decreasing trend of profitability from rice production (particularly, HYV *Boro*) was observed during 1980 to 2000 (Jahan and Jaim 2002) which continued up to 2006. However, as a result of rice price hike in the international market, farmers received high return from rice production during 2007 and 2008. But, in 2009 rice price declined drastically which adversely affected farmers' profitability (Mia 2009).

The decline in profitability from paddy production can be attributed to the following reasons:

- The rate of increase in farm gate price of paddy is lower compared to rate of increase of the price of inputs like seed, fertilizer and irrigation as well as agricultural labor wage.
- Liberalization in the agriculture sector created an unregulated market where paddy producing farmers get less and traders / rice millers get more due to market syndication.
- Most of the paddy producing small farmers have to sell paddy at a lower price in the harvest season to meet their immediate cash needs. On the other hand, the millers / traders have their own network and capacity to appropriate extraordinarily high price from the consumer's end.

SUMMARY AND CONCLUSIONS

Sustainable increase of agricultural production requires efforts to enhance the capacity of the production system so that resilient growth of the rural economy is being made possible. Despite major improvements in food grain production, agricultural inputs continue to experience problems such as lack of timely availability, poor quality, and high price. Poor farmers in remote areas lack adequate information and their problems are more marked. The following issues are pertinent in this view.

Fertilizer demand management

Fertilizer deficit is a major problem for smallholder farmers. Subsidy provided by the government should be targeted towards smallholder farmers. Debates are surrounding on the economic and social issues of subsidy such as price distortion and social barriers to access resources and their impacts in production. On the one hand, subsidy leads to inefficient allocation of resources through disturbing the price signals in the market. On the other hand, resource poor farmers use inputs suboptimally in the existing market and social conditions. Subsidy may be considered a 'correcting device' to address issues of imperfection in the agriculture sector. This suggests introducing selective targeted subsidy but better methods should be employed to reach only the poor farmers. This argument directs research needs in the area of examining the costs and benefits of targeted subsidy in the agriculture sector.

Re-introduction of fertilizer subsidy

Re-introduction of subsidy is well praised from all sections of the society because of its positive impact on production. However, subsidy should be targeted towards poor farmers only to cope with the pressure on exchequer and to stop overuse that could damage environment. Appropriate targeting method needs to be identified. Failure of liberalized markets may lie in the system of regulation. Farm level studies indicate that poor farmers are paying high price for fertilizer as well as facing the problem of timely unavailability. Thorough investigation is necessary to find means to solve fertilizer crisis.

Organic farming and fertilizer

Opportunity remains in the expansion of organic farming to reduce the use of chemical fertilizers. Along with advantages, some serious problems could occur from the overuse of some organic materials. Efficient use of organic sources needs to be identified. The country has the potential to increase the number biogas plants to meet fertilizer crisis.

Seed for vulnerable farmers

Rice production has increased due to the introduction of HYV seeds but at the same time the demand for complementary modern inputs like fertilizers and irrigation has also increased. Farmers became more vulnerable to production losses arising from the volatility of the input market as well as natural causes that has been rising due to climate change. The marginal farmers are more vulnerable because they have limited access to resources.

Quality seed supply

Adequate supply of quality seed is particularly important in Bangladesh, where natural disasters occur frequently, resulting in total loss of farmer seed stocks in some areas. Home grown seed still a major source of supply with lower quality. Farmers should have access to information on quality control of their own seed.

Biotechnology and seed

Proper use of biotechnology is necessary for sustainable growth of production. Using biotechnology we can now modify the seeds to be 'disease-free' but in doing so it could actually create harmful things like a super-virus, which could wipe out our entire supply of food. On the other hand, many biotechnology applications are environmentally focused, impact oriented and complementary to conventional breeding. Given the private sectors huge investment in biotechnology in developed countries, researchers in public sector institutions are now wisely choosing target traits and environments that can substantially impact low-income farmers and consumers. Private sectors should be appropriately regulated so that they use biotechnology to benefit low-income farmers.

Hybrid seeds

By increasing *Boro* areas by 50 percent and other rice areas by 25 percent under hybrid rice, Bangladesh can potentially increase rice production adequately to meet food security, the primary objective of the National Agricultural Policy. Farmers have been paying very high prices for hybrid seeds, which they buy from private traders; poor farmers pay even higher prices. Farmers often buy low quality seeds from the traders as it is not possible to verify the quality of the hybrid seeds. Farmers should be protected from this type of market failure. Private sector is more involved in importing unregulated hybrid seeds. The impact of this unregulated imports and marketing should be identified through impartial research.

Irrigation

There is lack of research to measure social costs and benefits of water use. Also, there is inadequate research on the current constraints on irrigation and the resulting consequences on farmers' income, farm productivity and poverty.

Agricultural innovation

Good quality research is extremely limited in the areas of regional differences in agricultural production and innovative means to improve productivity considering regional factors. Research capacity and number of researchers appear to have been reducing due to inadequate funding and brain drain. Research is necessary to identify any other particular reasons to improve the situation. Comprehensive information on agricultural research and development conducted by the private sector is limited. Private sector is coming forward to conduct collaborative research with government research organizations but the extent is extremely limited. This type of collaboration should be encouraged.

Agricultural extension

Extension services in Bangladesh are provided by the DAE, which has a strong organizational set up with trained personnel. In addition, public research cum extension organizations, donor supported rural development program, NGOs, private agro-chemical input suppliers, public community development and agricultural extension service providers, etc. are also involved in providing extension services. In spite of policy reforms and various attempts, the services provided by these stakeholders are not enough in the context of farmers' benefit. Especially innovations are still not suitable to reach the extension services to remote areas such as the area of *Char, Haor*, river bank and coastal areas. Mobile phone supported technology may be developed to inform the farmers of remote areas with new inputs, methods and practices that could enhance the productivity. There is insufficient information on the number of farmers who are actually reached and serviced by the DAE. Large scale farmers perceive the DAE as generally not competent enough to provide advisory services necessary for commercialization.

On the other hand, adoption of available technologies has not reached expected levels within the smallholdings, which have very low productivity.

Constraints to small and marginal farmers

Research identified the need to increased access by small and marginal farmers to right quantity and quality of inputs like fertilizers, seeds and extension services on time but it is not known how can they be accessed? There is gap in the existing literature on identifying the method of reaching the small and marginal farmers with agricultural inputs.

Input markets

Input markets in Bangladesh followed a path of evolutionary reform since independence of the country in 1971. The policies can be broadly categorised into subsidy based government monopoly regime and liberalized market regime. In both cases, benefits are reaped by large farmers and rural elites. In both policy regimes, gaps exist in the case of recommended dose and actual use of inputs. In order to increase competitiveness and efficiency, input markets were liberalized. The liberalizers promised of lower input prices; they argued that availability of different types of resources due to the internationalization of the market would lead to balanced and sustainable use of inputs in the fields. In practice, the use was disproportionate. The government needs to give subsidy to poor farmers. The market based system puts the small farmers in disadvantage position, because they are unable to compete with the large farmers due to various socio economic constraints.

So far there have been many changes in the policies related to agricultural inputs but none of them particularly favoured small and marginal farmers. There is lack of social cost benefit analysis to identify whether society as a whole is benefiting from policy changes. Both subsidy and liberalized policies are disproportionately benefitting the rural elites and large farmers. So policies and programs should reconsider the needs of small and marginal farmers.

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