# AGRICULTURAL TECHNOLOGY ADOPTION IN THE FEED THE FUTURE ZONE OF INFLUENCE IN BANGLADESH

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International Food Policy Research Institute

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# 1. INTRODUCTION

Technology is the basis for sustainable agricultural growth. Enhanced agricultural productivity and growth depend, to a large extent, upon the widespread adoption of appropriate technologies by farmers.

Seed, fertilizer and irrigation technologies known as “Green Revolution technologies” have long played major roles in the growth of agriculture production in Bangladesh. The country has made commendable progress in domestic rice production through farmers’ adoption of these technologies. In the early 1970s, Bangladesh was a seriously food-deficit country with a population of about 75 million. Today, the population is more than 160 million, and Bangladesh is on the brink of self-sufficiency in rice production, which has tripled over the past three decades.

Upon request from the US Agency for International Development (USAID), the International Food Policy Research Institute’s Policy Research and Strategy Support Program in Bangladesh (IFPRI-PRSSP) developed and began a study on the adoption of agricultural technologies in USAID’s Feed the Future (FTF) zone of influence in the south and southwest regions of the country. FTF is the US government’s global hunger and food security initiative to support country-driven approaches to address the root causes of poverty, hunger, and undernutrition. In Bangladesh, FTF’s collective efforts aim to improve the livelihood and nutritional status of households through: (1) increased on-farm productivity, (2) increased investment in market systems and value chains, (3) enhanced food security policy and planning capacity, (4) enhanced agriculture innovation capacity, and (5) improved nutritional status of rural poor.

The agricultural technologies evaluated in this study are:

1. Urea deep placement (UDP)—popularly known as “Guti urea”; and
2. Modern, stress-tolerant varieties of rice.

This report presents results of analyses of survey-based data on the adoption of UDP and stress-tolerant rice varieties by rice farmers in the FTF zone of influence. The report is organized in seven sections. Section 2 describes the survey that provided the data used in the empirical work. Section 3 gives a profile of survey households. Section 4 presents the results of analyses of the usage of the UDP technology by farmers. Section 5 discusses the findings of analyses of farmers’ usage of modern, stress-tolerant varieties of rice technology. Section 6 provides an analysis of the determinants of farmers’ adoption of technologies and the duration of adoption. Section 7 summarizes the main findings and provides policy conclusions.

## 2. DATA

The data for the study came from the 2013 IFPRI-PRSSP Agricultural Technology Adoption Survey of 2,400 rice farmers in the FTF zone of influence.

### 2.1 Sampling

The FTF zone level survey is statistically representative of all rice farmers in the FTF zone and its domain included all 120 FTF upazilas within the 20 FTF districts. The sampling process and survey administration included the following steps:

1. List all villages in each of the 120 FTF upazilas from the 2011 National Population Census.
2. Randomly select two villages in each upazila with probability proportional size (PPS) sampling, using the village-level population data from the 2011 National Population Census.
3. Conduct complete census of each of the 240 selected villages.
4. List all farm households that cultivated rice in the 12-month period prior to the survey, then randomly select 10 farm households from village census list.
5. Conduct interviews of 2,400 selected rice-farm households.

### 2.2 Survey Questionnaire

The IFPRI-PRSSP team prepared a draft questionnaire for the agricultural technology adoption survey, received comments on the draft questionnaire from USAID, and revised the questionnaire by addressing the comments. The questionnaire included eight modules: (1) sample household identification; (2) household composition, literacy, and education; (3) roster of land owned or under operation; (4) plot-level information on seeds, irrigation, and urea fertilizer usage; (5) information on use of Guti urea; (6) information on usage of paddy varieties; (7) information on use rate of paddy seeds; and (8) access to credit.

### 2.3 Training and Survey Administration

IFPRI contracted the Data Analysis and Technical Assistance (DATA) Limited, a Bangladeshi consulting firm with expertise in conducting complex surveys and data analysis, to implement the survey. DATA worked under the supervision and guidance of senior IFPRI researchers. (DATA's capacity to conduct surveys and collect high-quality data was largely built by IFPRI during the past two decades.[1])

[1] In the past two decades, DATA has carried out all IFPRI surveys in Bangladesh, including more than 50 household surveys and several market, school, and other institutional surveys. In addition, DATA has conducted numerous surveys for various international organizations, including CARE-Bangladesh, the European Union, the IRIS Center at the University of Maryland, the Population Council, Save the Children (USA), Tufts University School of Nutrition Science and Policy, the US Department of Agriculture, the World Bank, the World Food Programme-Bangladesh, and World Vision-Bangladesh.

DATA provided 100 experienced survey enumerators and 20 supervisors to administer the surveys. IFPRI-PRSSP provided the survey questionnaire to DATA for the training of the survey team. DATA translated the questionnaire into Bangla. IFPRI-PRSSP researchers and senior DATA staff pre-tested the questionnaire in the FTF zone and trained survey workers, in both a formal classroom setting and closely monitored practice fieldwork.

DATA conducted the survey from November 1 to 19, 2013 under IFPRI-PRSSP supervision. DATA completed the survey of 2,400 farm households by engaging 20 teams consisting of 6 members per team (5 enumerators and a supervisor). The enumerators conducted one-on-one, face-to-face interviews with the respondents assigned to them, under the supervision of their field supervisor. To show appreciation for respondents' time, a gift of two plates and one bowl (a 200-taka value) was given to each household. Completed questionnaires were sent to the DATA central office in Dhaka on a regular basis for simultaneous data entry. IFPRI and DATA took extensive care to ensure the quality of the household survey data, and IFPRI researchers made field visits to supervise the fieldwork.

### 2.4 Data Entry, Cleaning, and Analysis

Staff at the DATA office in Dhaka carried out the data entry simultaneously during data collection, with about four days of lag time. DATA used a software specialized for data entry (Microsoft Access) that was programmed to identify out-of-range or inconsistent values.

After receiving the cleaned dataset from DATA, IFPRI-PRSSP researchers analyzed the data using Stata software. Senior IFPRI researchers provided guidance for data analysis.

# 3. PROFILE OF SURVEY FARMERS

Using data from the 2013 IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF zone, this section presents the profile of rice-farm households living in the FTF zone of influence. Much of the farmer-level analysis in this study disaggregates the sample farmers into four operated farm size groups: (1) marginal (farmers operating less than half an acre of land); (2) small (farmers operating 0.5 to 1.49 acres); (3) medium (farmers operating 1.5 to 2.49 acres); and (4) large (farmers operating 2.5 acres or more).

The ranges of farm size groups are the same as those used in the IFPRI-PRSSP report of the 2011–2012 Bangladesh Integrated Household Survey (Ahmed et al. 2013). The four farm size groups match the cut-off points of the six operated farm size groups presented in the 2010 Household Income and Expenditure Survey (HIES) report of the Bangladesh Bureau of Statistics (BBS 2011) by aggregating the smallest two HIES farm size groups under the marginal farm category and the largest two groups under the large farm category.

## 3.1 Household Characteristics

Table 3.1 shows household size, educational attainment, and literacy rates of sample households in the FTF zone survey by farm size groups. Smaller rice-farming households tend to be a bit smaller than larger farm households; the average household size declines from 5.6 for the large farm group to 4.6 for the marginal farm group in the FTF zone.

The following are additional highlights of household characteristics:

- Primary school-age children (age 6–10) from about 8 percent of rice farm households and secondary school-age children (age 11–18) from 25 percent of rice farm households in the FTF zone do not go to school.
- Educational attainment in terms of years of schooling of male household head and wife of household head is positively correlated with farm size.
- Educational attainment in terms of years of schooling of adult family members is positively correlated with farm size.
- In the FTF zone, 36 percent of adult males and 43 percent of adult females in rice farm households never attended school. The rate of no schooling of adults declines as farm size of households increases.
- A person who can read and write a sentence in Bangla is considered to be literate. Table 3.1 shows the literacy rates for ages 15 and above. Overall, the female population has a lower literacy rate than the male population. Literacy rates have strong, positive relationships with farm size.

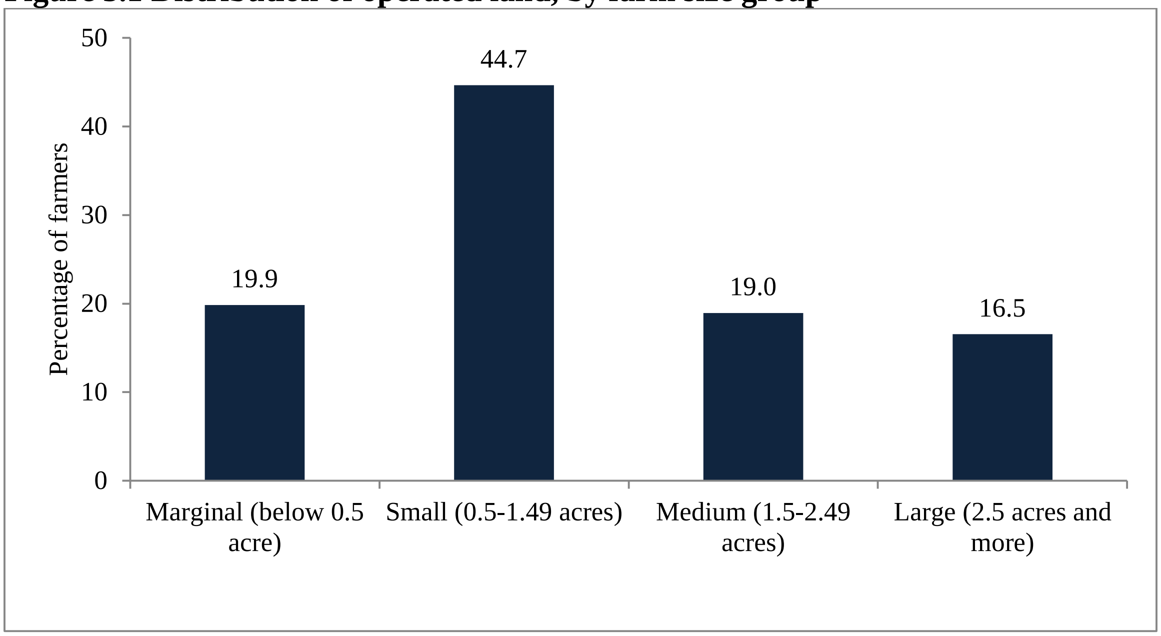
## 3.2 Inequality in Distribution of Operated Land

Land is the most important factor of agricultural production. However, about one-fifth of the rice farmers in the FTF zone are pure tenants, that is, they do not own any cultivable land. These farmers have either sharecropping or cash-lease arrangements with landlords for their operated land (see section 3.4). Table 3.2 describes the pattern of distribution of operated land in the FTF zone, the simplest way to measure inequality. In the table, the sample rice farm households are divided into 20 equal groups and are ranked from lowest to highest according to the size of their total operated land. The average size of operated land for each group is also reported in the table. The figures indicate that the distribution of operated land is highly unequal. The bottom 25 percent of all rice-farm households own only 6.5 percent of total operated land in the FTF zone. At the other extreme, the top 5 percent of all households own 22.5 percent.

### 3.3 Farm-Size Groups and Size of Operated Land

Figure 3.1 shows the distribution of operated land by each of the four farm size groups as a percentage of all rice farmers in the FTF zone. Small farmers dominate the FTF zone—about 45 percent of all rice farmers are small farmers.

**Figure 3.1 Distribution of operated land, by farm size group**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

Table 3.3 shows the size of operated land by farm size groups as a percentage of all rice farmers in the FTF zone. The average size of operated land per rice farm household is 1.6 acres, ranging from only 0.3 acre per marginal farmer to 4.3 acres per large farmer.

### 3.4 Patterns of Land Tenure

Table 3.4 presents land tenure arrangements by farm size groups in the FTF zone. About one-fifth of all rice farm households are pure tenants, meaning they do not own any cultivable land. About 49 percent of rice farmers cultivate only their own land. The proportion of mixed-tenant farmers—those who cultivate their own land and also take land in as sharecroppers and/or leaseholders—is 31 percent.

The dominant tenurial arrangement in the FTF zone is sharecropping, where the produce is shared between the cultivator and the landowner in different proportions that have been agreed upon prior to cultivation. About 31 percent of the rice farmers are sharecroppers. This group of sharecroppers includes those who do not own any cultivable land (that is, “pure tenant”) as well as those who own land and sharecrop other people’s land. About 15 percent of the rice farmers have cash-lease arrangements either as pure tenants or as those with their own land plus cash-leased land. The proportion of rice farmers operating both sharecropped and cash-leased land (either as tenants or landowners) is about 5 percent (calculated from Table 3.4).

About 56 percent of all marginal farmers in the FTF zone do not have any land lease arrangements; they cultivate only their own land. This is perhaps a manifestation of their risk aversion. For the marginal farmers who are pure tenants (33.2 percent), the sharecropping arrangements represent an overwhelming majority—about 70 percent of all pure-tenant farmers are sharecroppers. Only about 13 percent of the large farmers are pure tenants, and 48 percent of them opt for sharecropping as the mode of renting land. It is interesting to note that about 47 percent of the large farmers supplement their own land with some form of sharecropping and/or cash leasing (Table 3.4).

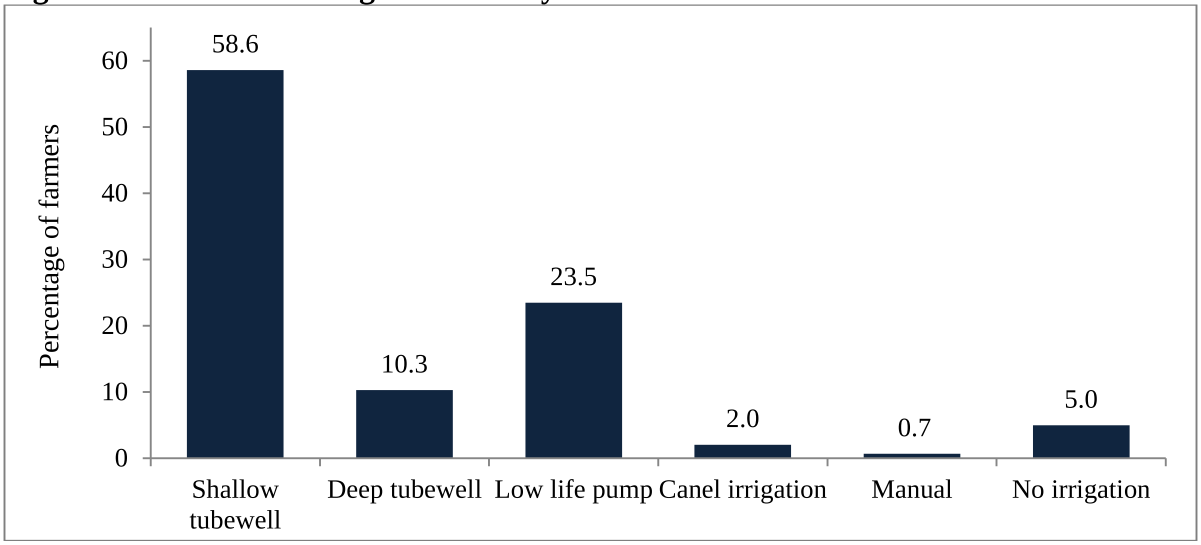
### 3.5 Irrigation

Irrigation is one of the most critical factors of agricultural production in Bangladesh. Tripling rice production in the country since the early 1970s would not have been possible without irrigation. It plays three crucial roles in increasing foodgrain production in Bangladesh: (1) irrigation enables farmers to grow an additional boro rice or wheat crop during the dry winter season and thus increases cropping intensity and eases the land constraint; (2) irrigation complemented with fertilizers and modern high-yielding rice varieties significantly raises rice yields in comparison to rain-fed rice cultivation; and (3) supplemental irrigation can take much of the risk out of the two predominantly rain-fed rice seasons—aus and aman (Ahmed and Sampath 1992).

Bangladeshi farmers use both traditional and modern methods of irrigation. Traditional methods include *done* (a water-lifting devise), swing basket, and dug-well. Modern techniques include shallow tubewell, deep tubewell, low-lift pump, hand pump, and sophisticated canal gravity-flow irrigation schemes. Among these, *done,* swing basket, low-lift pump, and canal irrigation use surface water while dug-well, shallow tubewell, deep tubewell, and hand pump use groundwater as irrigation sources.

The shallow tubewell is the predominant method of irrigation used by about 59 percent of rice farmers in the FTF zone for boro rice cultivation. The second most important method is low-lift pump, used by more than one-fifth of the rice farmers. About 5 percent of the rice farmers cultivate boro rice without irrigation (Figure 3.2).

**Figure 3.2 Methods of irrigation used by farmers for boro rice cultivation in the FTF zone**

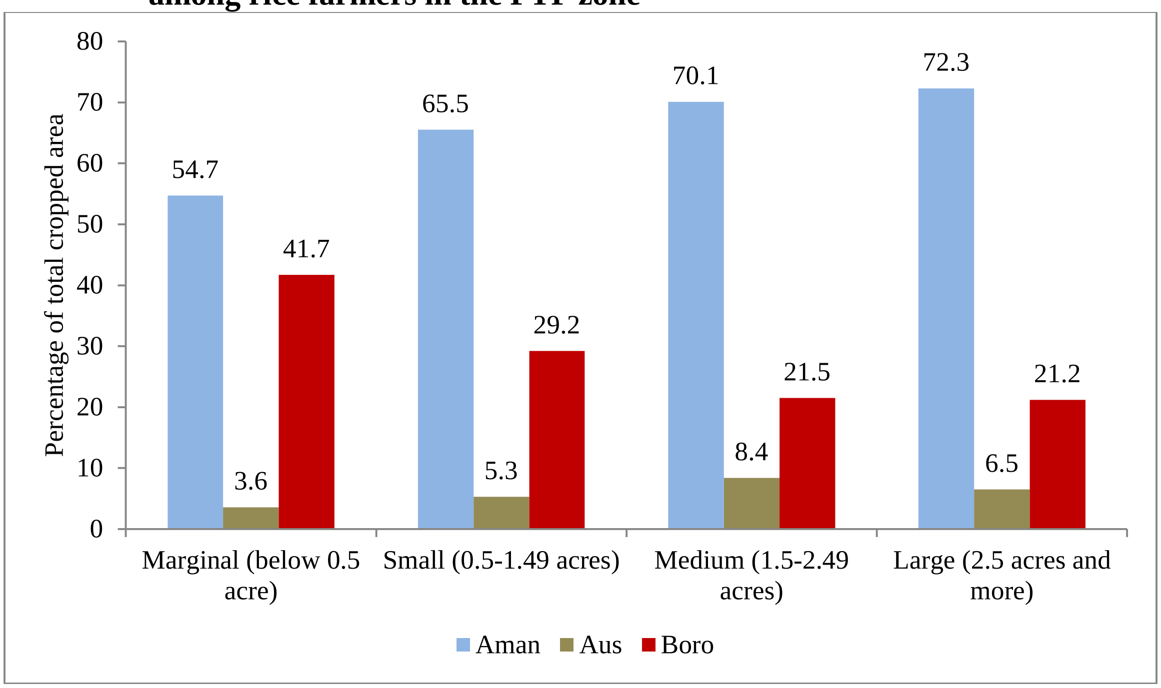



**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

### 3.6 Share of Rice Crops on Total Rice Land

Figure 3.3 shows the share of aman, aus, and boro rice crops on total rice land of farmers in the FTF zone. Aman and boro rice show opposite patterns across the four farm size groups: while the share of aman rice area increases as farm size increases, the relationship is negative in the case of boro rice crops.

**Figure 3.3 Share of aman, aus, and boro rice crops on total rice land, by farm size groups among rice farmers in the FTF zone**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

# 4. USAGE OF THE UREA DEEP PLACEMENT TECHNOLOGY

Urea deep placement (UDP)—popularly known as "Guti urea"—is promoted in Bangladesh by the Accelerating Agriculture Productivity Improvement (AAPI) project, which is funded by USAID and implemented by the International Fertilizer Development Center (IFDC) in collaboration with and the Department of Agricultural Extension (DAE) of the Ministry of Agriculture, Government of Bangladesh. Emphasis is on improving farmer access to and use of UDP technology to improve crop yields and economic returns to farmers.

This section presents the results of the FTF zone level survey on the usage of the UDP technology (Guti urea) by rice-growing farmers. It is important to note that the IFPRI-PRSSP survey sample represented all rice farmers in 120 upazilas that comprise the FTF zone of Bangladesh.

## 4.1 Usage by Percentage of Farmers

Table 4.1 presents the percentages of rice farmers who used Guti urea at least once for cultivation of crops harvested in 2013.[2] The results are disaggregated by rice, all crops (rice and non-rice together), and farm size. The results of the survey suggest that 10.8 percent of all rice farmers used Guti urea for crops harvested in 2013. The 95 percent confidence intervals of the rates of usage of Guti urea are from 9.5 percent to 12 percent for the FTF zone survey sample. The percentage of farmers who used Guti urea increases as farm size increases. The rate of use by large farmers is close to double the rate of use by marginal farmers. (Figure 4.1).

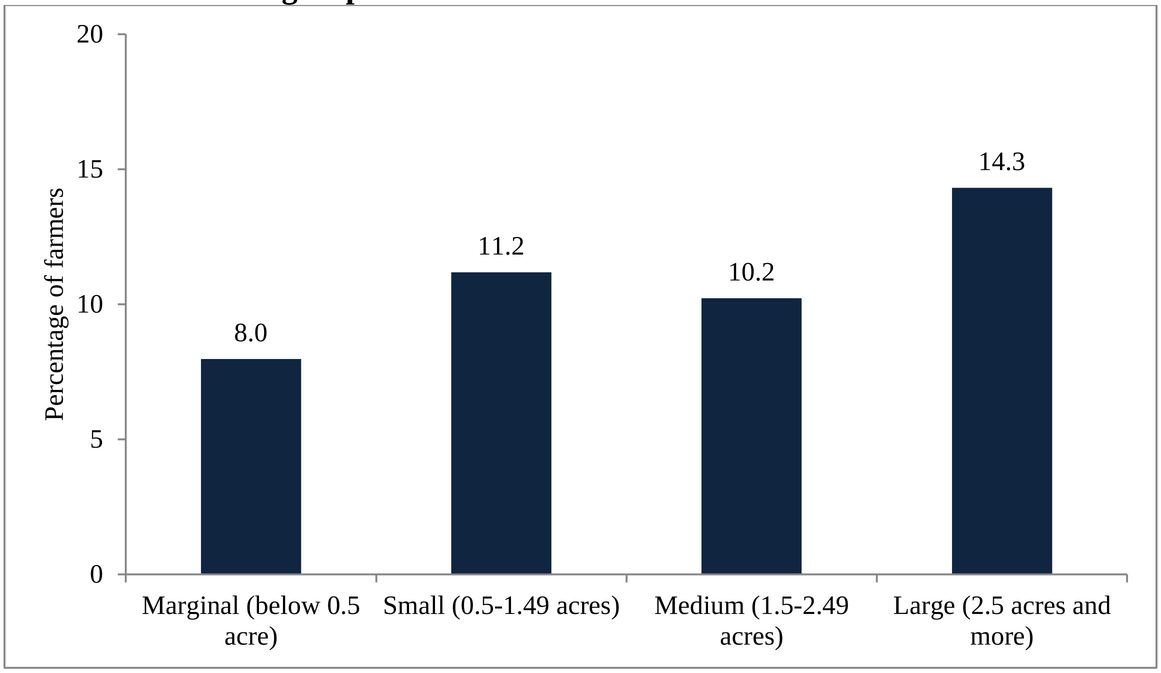
About 94 percent of the survey sample had heard about Guti urea from various sources. Among the most prevalent sources of information were fellow farmers, (77 percent) followed by fertilizer dealers then television (Table 4.2).

Among the three rice crops, the rates of use of Guti urea are highest for boro rice and lowest for aman rice. In 2013, 11.5 percent of farmers in the FTF zone used Guti urea with boro rice (Figure 4.2).

Guti urea usage has increased for the survey sample over time: while only 5.3 percent of all rice farmers in the FTF zone used Guti urea in 2010, the rate increased to 10.8 percent in 2013 (Figure 4.3).

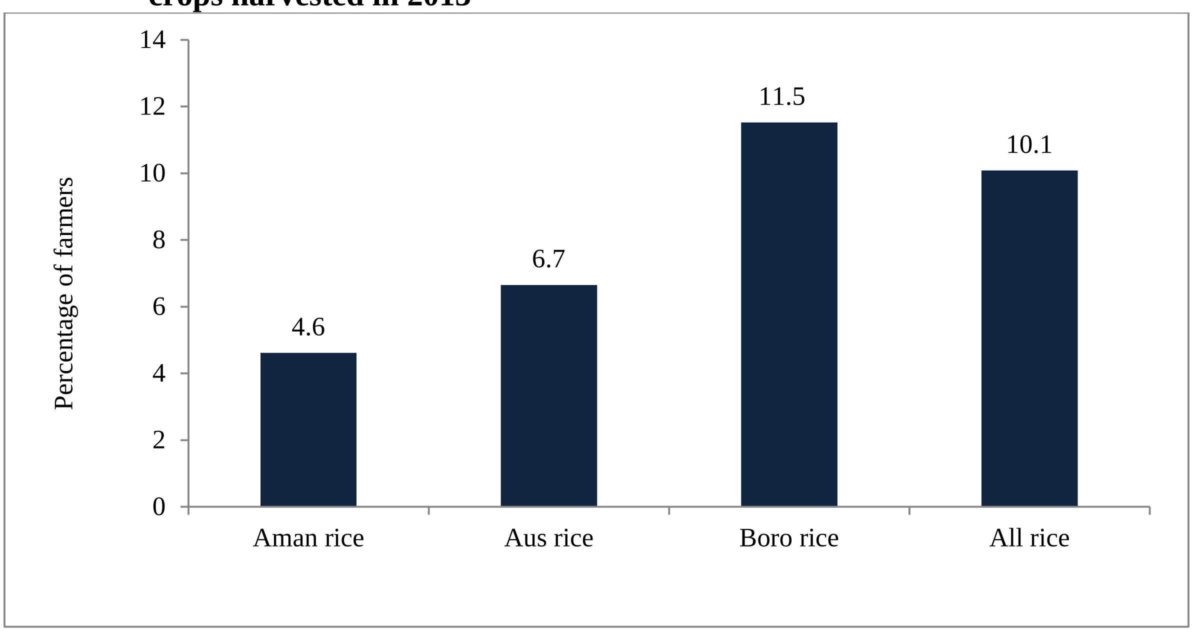
[2] The 2013 aman rice crop was partially harvested during the time period when the survey was being conducted (November 1–19, 2013).

**Figure 4.1 Percentage of rice farmers who used Guti urea for crops harvested in 2013, by farm size groups**



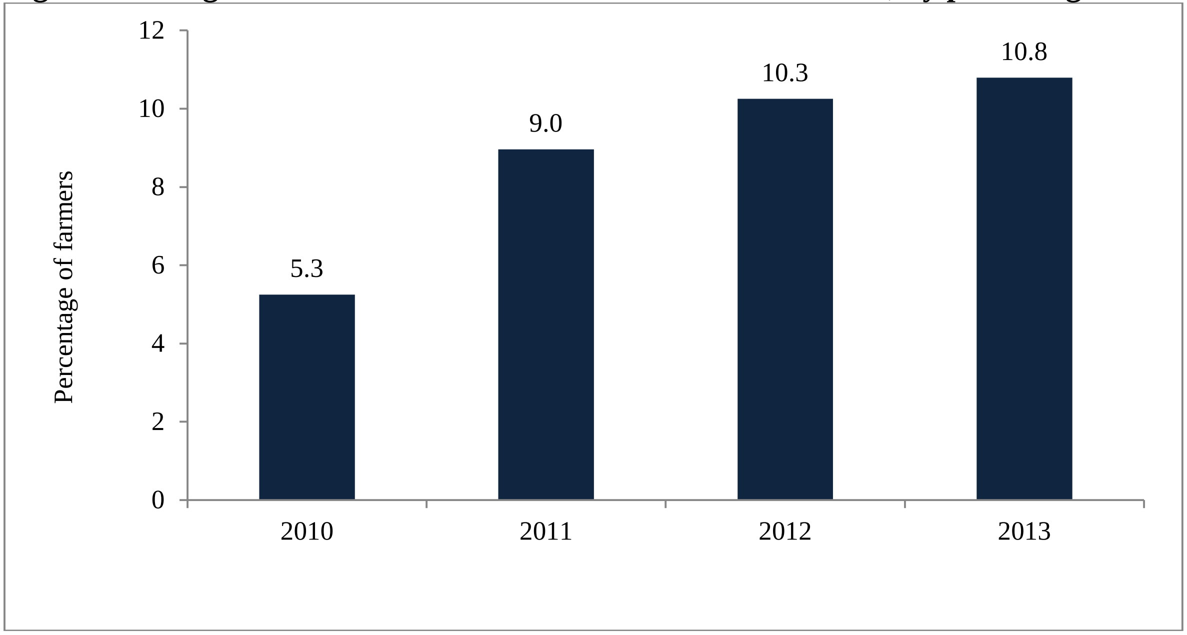

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

**Figure 4.2 Percentage of rice farmers who used Guti urea for aman, aus, and boro rice crops harvested in 2013**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

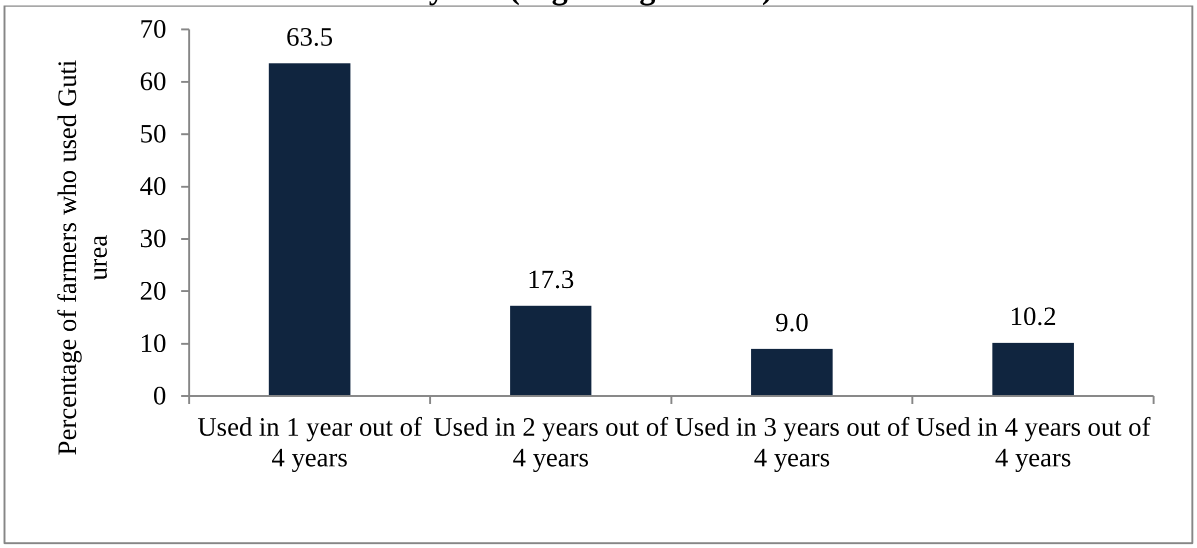
**Figure 4.3 Usage trends for Guti urea since 2010 in the FTF zone, by percentage of farmers**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

The results of the survey suggest that 21.2 percent of all rice farmers used Guti urea at least once since 2010. Figure 4.4 shows the annual frequency of usage of Guti urea in terms of percentage of farmers who used it in one year, two years, three years, and four years (beginning in 2010). For example, among the 21.2 percent of farmers in the FTF zone who used Guti urea at least once since 2010, 63.5 percent of them used it only in one out of four years, 17.3 percent in two out of four years, 9 percent in three out of four years, and 10.2 percent in four out of four years.

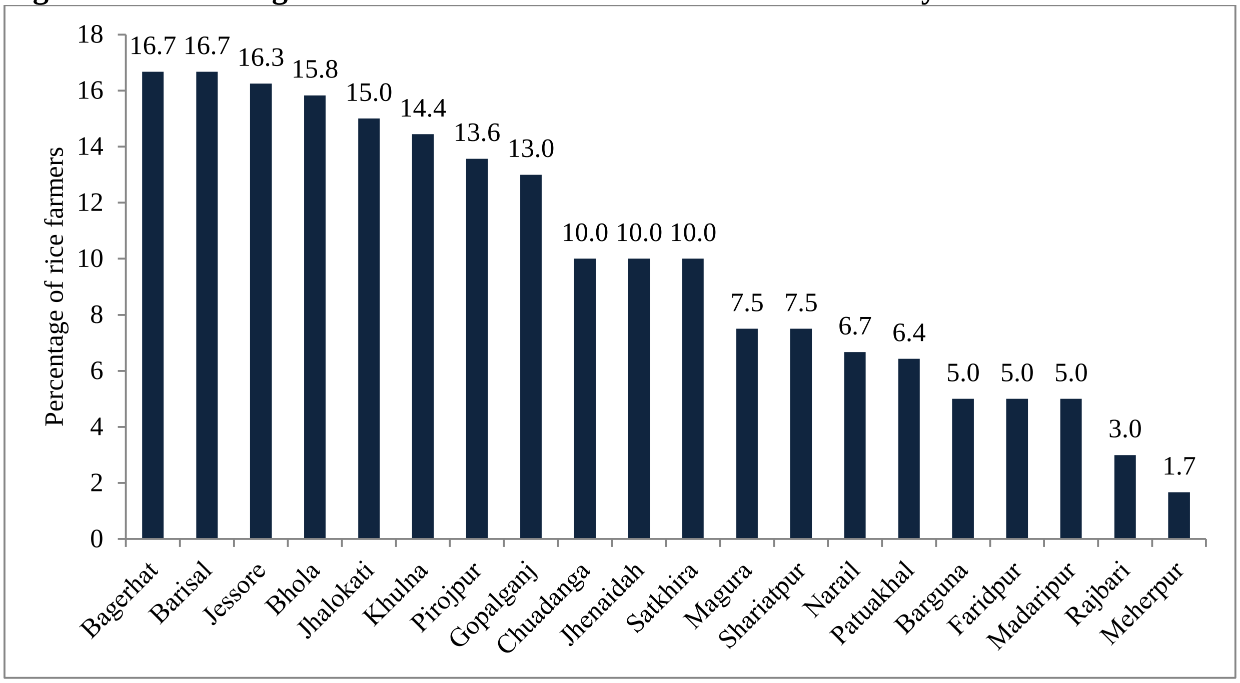
**Figure 4.4 Annual frequency of usage, by percentage of farmers who used Guti urea in at least one out of four years (beginning in 2010)**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

Figure 4.5 shows the rate of usage of Guti urea by rice farmers in each of the 20 districts in the FTF zone of influence. The rate varies between 16.7 percent in Bagerhat district to only 1.7 percent in Meherpur district.

**Figure 4.5 Percentage of rice farmers who used Guti urea in 2013 by districts in FTF zone**

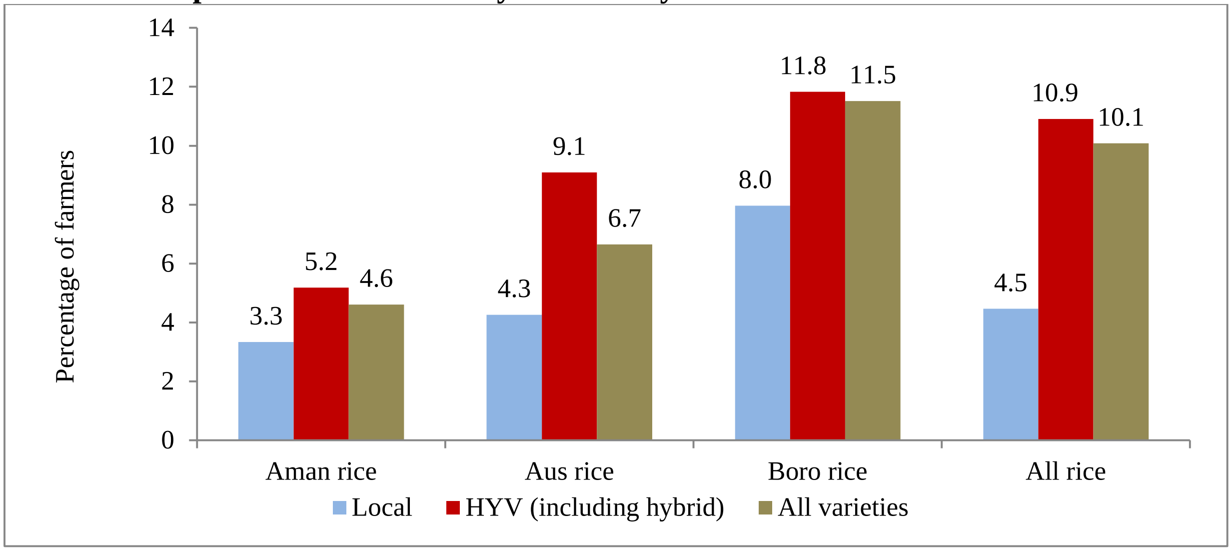



**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

Figures 4.6 presents the percentages of farmers in the FTF zone survey who used Guti urea at least once for cultivation of local or traditional varieties and high-yielding varieties (HYVs) of rice crops harvested in 2013. The figures reveal that rice farmers use Guti urea mainly to cultivate HYVs of rice.

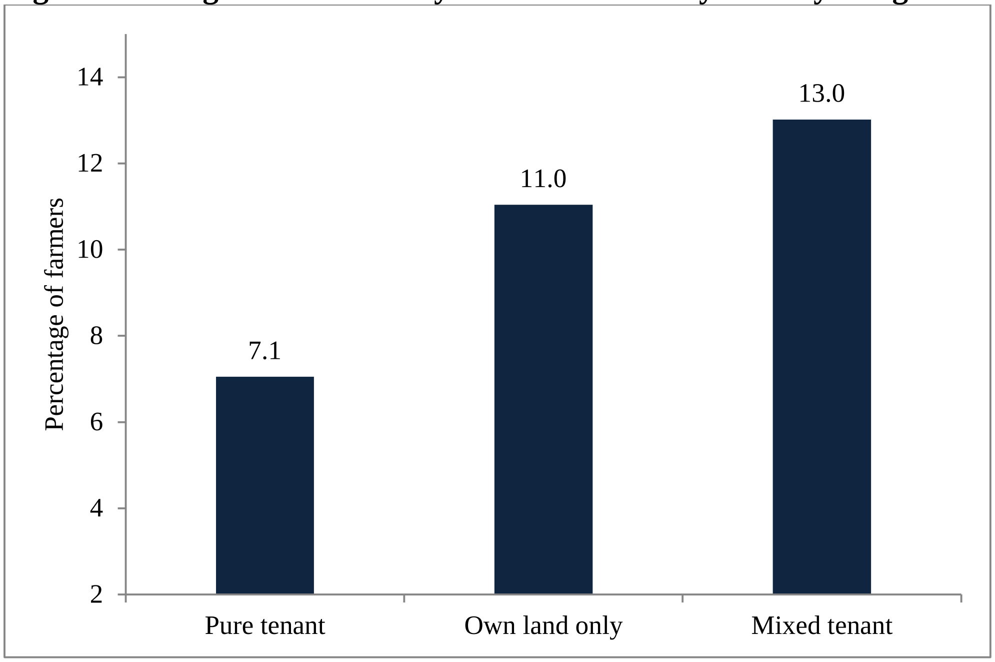
Figure 4.7 shows the use of Guti urea by types of tenancy of rice farmers for crops harvested in 2013: (a) those who do not own any cultivable land (pure tenants), (b) those who cultivate only their own land, and (c) those who cultivate their own land and also take land in as sharecroppers and/or leaseholders (mixed tenants). The rates of adoption of Guti urea are much lower for pure tenants than for those in the other two tenancy categories. In the FTF survey, only 7 percent of pure tenants use Guti urea for rice cultivation whereas 11 percent of farmers who cultivate only their own land and 13 percent of mixed tenants use it.

**Figure 4.6 Percentage of rice farmers who used Guti urea for aman, aus, and boro rice crops harvested in 2013 by rice variety**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

**Figure 4.7 Usage of Guti urea by farmers in 2013 by tenancy categories**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

## 4.2 Usage of Guti Urea by Number of Rice Farmers in the FTF Zone

As mentioned above, the results of the survey suggest that 10.8 percent of all rice farmers used Guti urea for crops harvested in 2013. Since the FTF zone level survey is statistically representative of all rice farmers in the FTF zone of influence, it is possible to estimate the number of rice farmers who used Guti urea for rice crops harvested in 2013. According to the 2011 Population and

Housing Census conducted by the Bangladesh Bureau of Statistics, there are 6,277,486 rural households in 120 FTF zone upazilas in 20 FTF districts. IFPRI-PRSSP conducted the 2011-2012 Bangladesh Integrated Household Survey (BIHS), which is a nationally representative survey of rural Bangladesh as well as statistically representative of the FTF zone of influence. From the BIHS dataset, we have calculated that 51.9 percent of all households in the FTF zone cultivated rice in 2011. Therefore, the total number of rice farm households in the FTF zone is 3,258,015 (that is, 6,277,486 *0.519], of which 10.8 percent or 351,866 rice farmers have used Guti urea in 2013.

### 4.3 Coverage of Cultivated Area

Table 4.3 shows the percentage of rice farm area under Guti urea application, disaggregated by rice-crop type (aman, aus, or boro), and farm size. In the FTF zone, 4.8 percent of rice farm area was under Guti urea application. The 95 percent confidence intervals of the percentage of farm area under Guti urea are from 4.1 percent to 5.5 percent for the FTF survey sample. According to the Bangladesh Bureau of Statistics, 2,794,571 hectares were under rice cultivation in the 20 FTF districts in 2012/13. The coverage of 4.8 percent of total rice farm area of the FTF zone under Guti urea application translates into total area of 134,139 hectares (that is, 2,794,571 x 0.048).

Among the three rice crops, boro rice had the largest percentage of area under Guti urea application, followed by aus (Table 4.3). The rates of coverage under individual rice crops are often higher than the aggregate. This is because of varying rates of cultivation in the three rice seasons with only a small percentage of farmers even cultivating aus rice at all (Figure 3.3).

### 4.4 Amount of Guti and Prilled Urea Used by Farmers

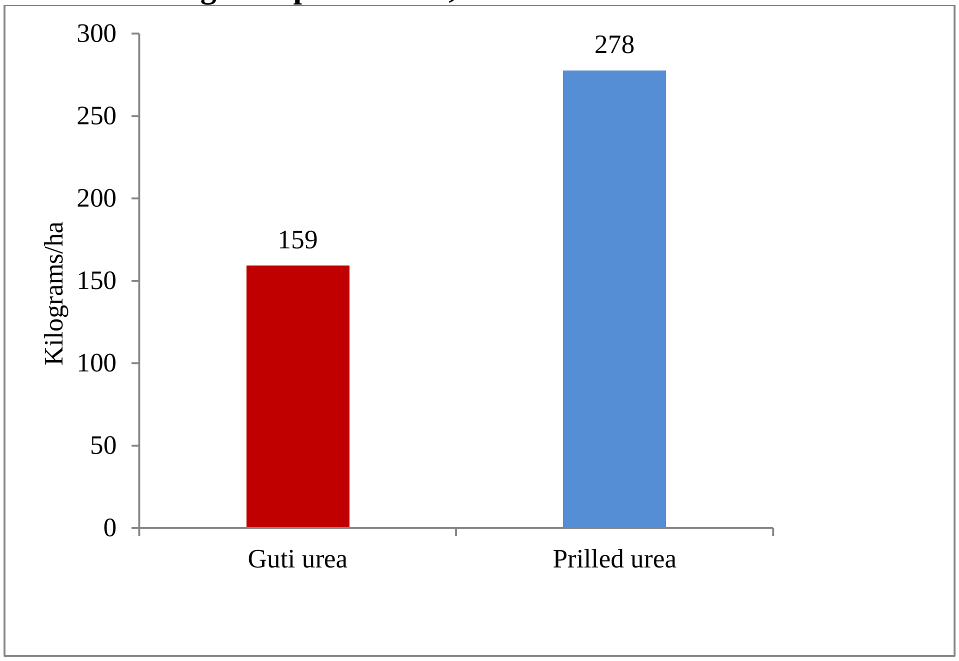
Figure 4.8 shows the estimated amount of Guti and prilled urea applications per hectare for boro rice cultivation, based on plot-level survey data. Plots using only Guti urea or only prilled urea were considered for the estimations. Farmers used 42.7 percent less Guti than prilled urea (because less Guti urea is required for cultivation than prilled) for boro rice cultivation.

### 4.5 Effects of Guti Urea Usage on Rice Productivity

In Figure 4.9, the results of the survey suggest that the paddy yields per hectare are substantially higher for the Guti urea users compared with prilled urea users, although the quantity of application of Guti urea per hectare was considerably less than that of prilled urea.

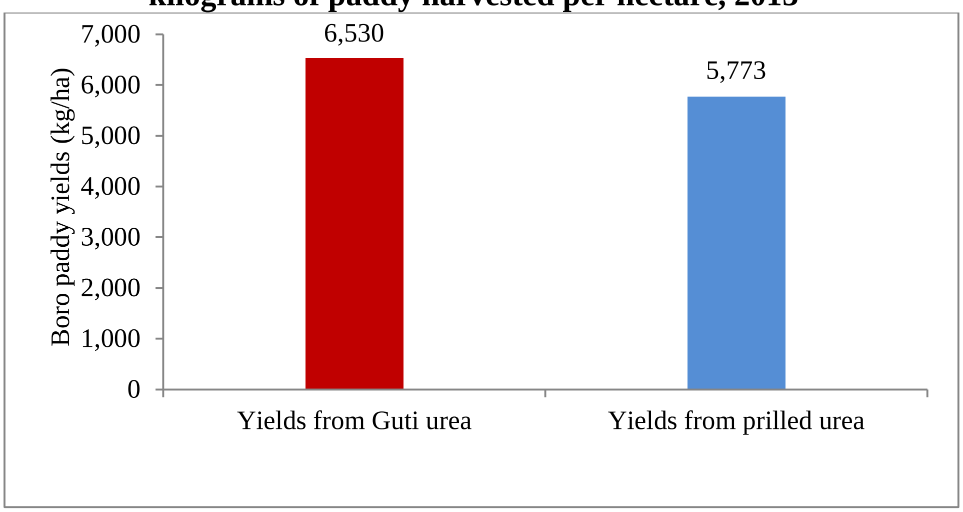
Farmers who exclusively used Guti urea for boro rice cultivation had 13.1 percent higher paddy yields than farmers who exclusively used prilled urea in the FTF zone of influence.

**Figure 4.8 Amount of Guti versus prilled urea applied for boro rice cultivation in kilograms per hectare, 2013**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

**Figure 4.9 Yields of boro paddy on land cultivated with Guti versus prilled urea in kilograms of paddy harvested per hectare, 2013**

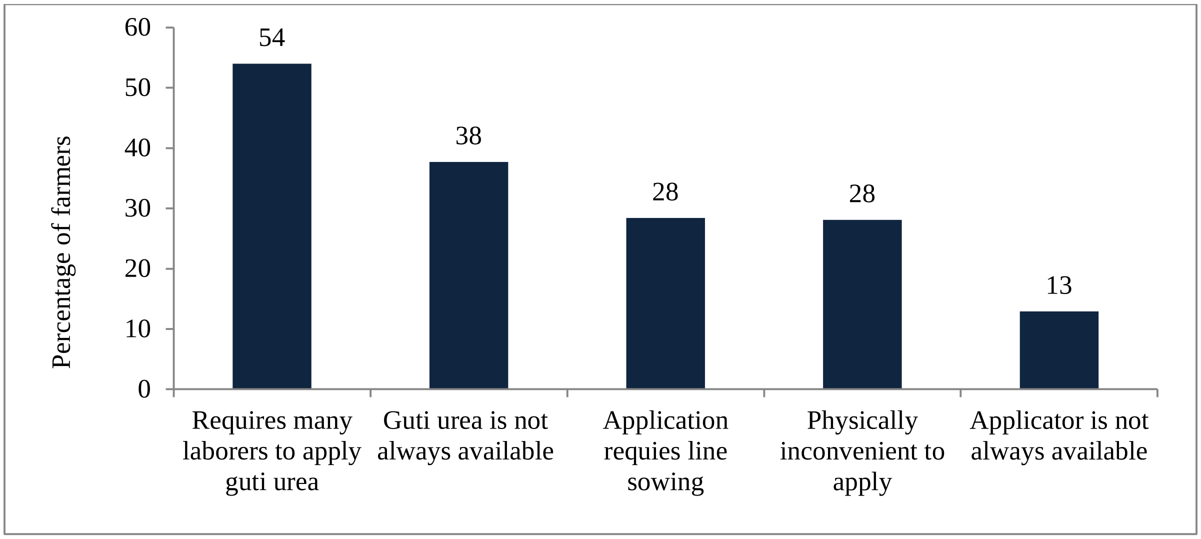



**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

### 4.6 Reported Reasons for Not Using Guti Urea

If paddy yields are high with relatively low amounts of Guti urea application, why don't more farmers in the FTF zone use Guti urea for crop cultivation? Farmers participating in the survey provided a variety of reasons, shown in Table 4.4. The farmers in the survey sample cited the high labor requirement as the dominant reason for not using Guti urea, followed by unavailability of Guti urea (Figure 4.10).

**Figure 4.10 Major reasons farmers reported for not using Guti urea, by percentage of farmers**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

# 5. USAGE OF STRESS-TOLERANT RICE VARIETIES

Since new varieties of notified crops[3] from public research institutes require official release and are subject to lengthy regulatory procedures involving multiple agencies, national and international research institutes in Bangladesh jointly adopted the strategy of pre-release seed multiplication and promotion with the aim to create awareness and generate demand for more varieties of rice seeds.

The Bangladesh Institute of Nuclear Agriculture (BINA), the Bangladesh Rice Research Institute (BRRI), the Bangladesh Agriculture University (BAU), and the International Rice Research Institute (IRRI) produced large quantities of breeder seeds for different stress-tolerant rice varieties during the boro 2012, aman 2012, and boro 2013 seasons. The rice varieties promoted by the research institutes include varieties that are salt-tolerant (BRRI dhan 47, 53, 54, 55, and 61; BINA dhan 8 and 10), submergence-tolerant (BRRI dhan 51 and 52; BINA dhan 11 and 12), and drought-tolerant (BRRI dhan 56 and 57). Varieties with both high grain quality and high market value were also promoted, including BRRI dhan 50, BRRI dhan 61, BINA dhan 11, and BINA dhan 12. Two major approaches were adopted for varietal promotion: (1) seed production from demonstration trials and supply of seed mini-kits (2.5 kilograms of seeds) to promote awareness among farmers; and (2) improving local availability of quality seed of new varieties for area expansion and farmer-to-farmer dissemination.

This section presents the results of the FTF zone level survey on the usage of the modern, stress-tolerant rice varieties by rice farmers in the Feed the Future zone of influence.

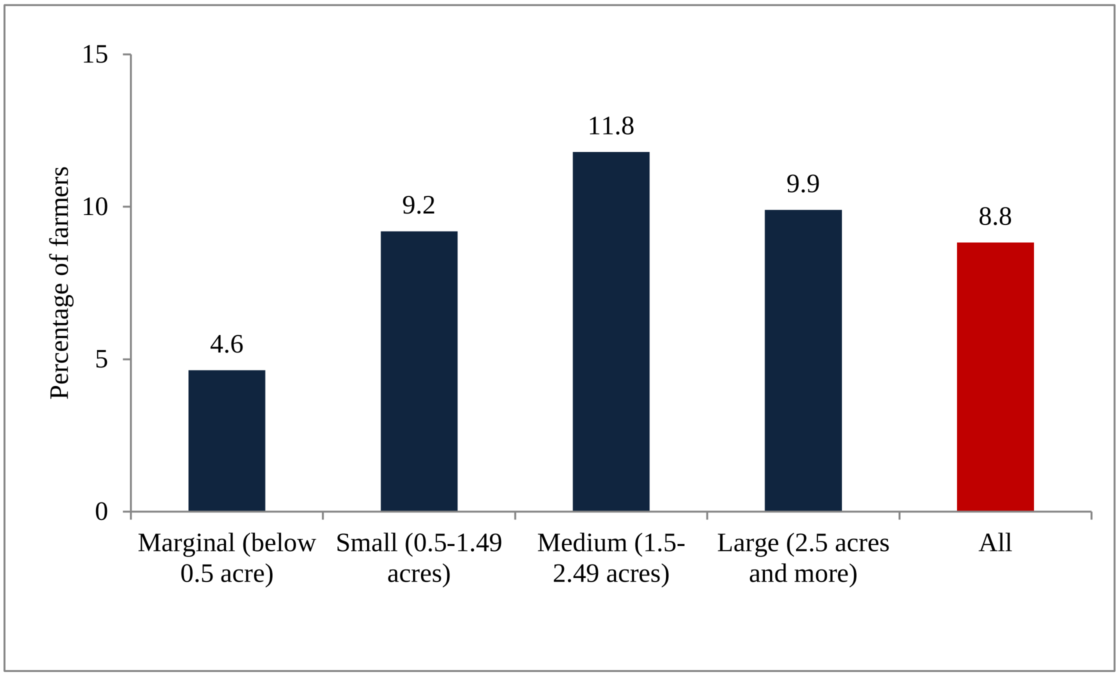
## 5.1 Usage of Modern, Stress-Tolerant Rice Varieties

In the FTF zone, less than one-tenth (8.8 percent) of the farmers grew at least one of the modern, stress-tolerant rice varieties promoted by the research institutes. Across the four farm size groups, adoption of these varieties is higher among the medium and large farmers. Among the marginal farmers, only 5 percent grew any of the promoted varieties (Figure 5.1).

A plausible explanation for the relatively low adoption of the stress-tolerant varieties by marginal farmers could be that these farmers are risk-averse given their lack of a diversified portfolio, which severely constrains their ability to offset any crop loss. It is understandable that these poor farmers prefer to stick to time-tested varieties with assured yields rather than experiment with new ones.

[3] Rice, wheat, potato, sugarcane, and jute are notified crops in Bangladesh, requiring the government to test the cultivars for performance prior to their approval.

**Figure 5.1 Percentage of farmers cultivating any of the stress-tolerant rice varieties promoted by research institutes, by farm size group, 2013**

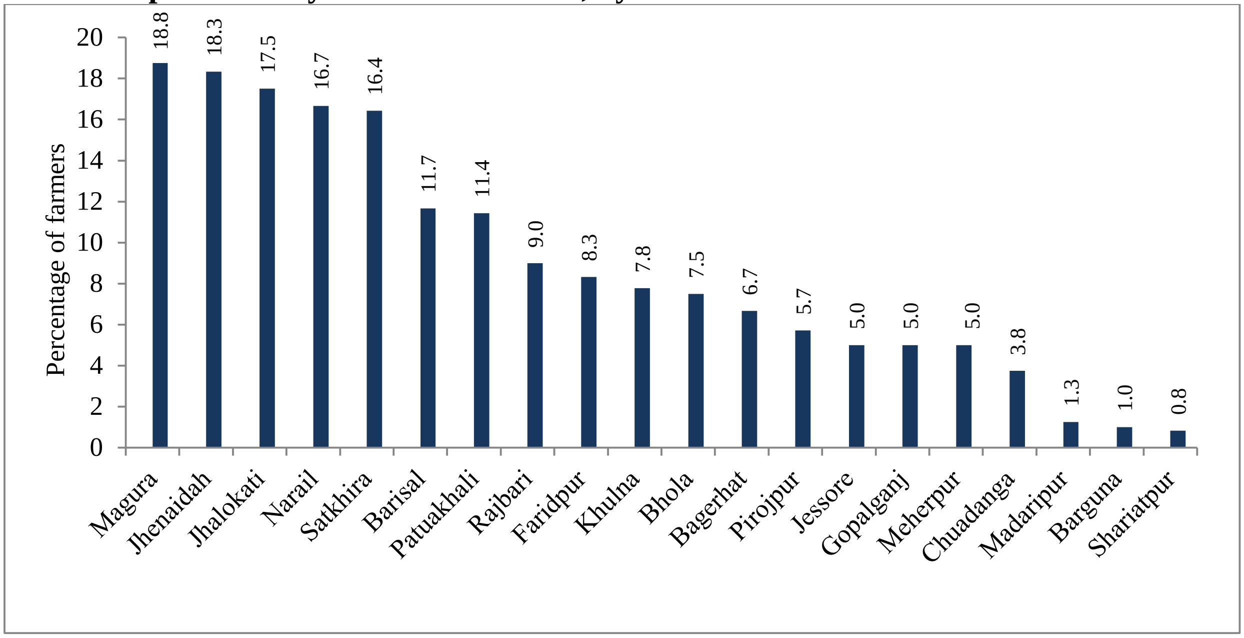



**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

Figure 5.2 presents the geographical distribution of adoption of stress-tolerant rice varieties promoted by the research institutes in the FTF zone of influence. The uptake of the stress-tolerant varieties is quite low across the 20 FTF districts, ranging from less than 1 percent in Shariatpur district to 19 percent in Magura district.

In the FTF zone, a wide variety of paddy is grown with no overwhelming majority of any one variety over another. We identified the 10 most popular rice varieties. Table 5.1 shows the percentage of farmers cultivating each of these 10 popular rice varieties in 2013. The highest adoption for aman is Guti Shorna (grown by 10 percent of the farmers), which is of Indian origin and may have been introduced to Bangladesh through informal cross-border exchange. This is followed by Mukta BR 11. In the boro season, 39 percent of the farmers grow BR 28 followed by BR 29 in the FTF zone. Overall, BR 28 and BR 29 dominate. BR 28 and BR 29 are rice varieties that were first grown in Bangladesh two decades ago, and, despite the introduction of many varieties since then, farmers continue to grow—and often prefer—it. A reason for the continued popularity of these two varieties is their higher yields and shorter growth cycle (for BR 28), which allows farmers to increase their cropping intensity.

**Figure 5.2 Percentage of farmers cultivating any of the stress-tolerant rice varieties promoted by research institutes, by districts in FTF zone in 2013**




**Source:** IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

Since 2000, most farmers have taken to growing BR 28 at different points of time (Table 5.2). However, it's worth noting that about 2 percent of the FTF zone farmers have given up growing BR 28 during 2009-2013 (Table 5.3). The variety that the maximum number of farmers have given up since 2000, however, is BR 11 (Mukta), which is a first-generation high-yield variety (HYV) rice that was introduced in Bangladesh more than three decades ago. These HYVs, though effective in areas of high potential, do not perform well under stressful agro-ecologies such as soil salinity or submergence conditions. Given that a substantial part of the FTF zone falls under this category, it is understandable why farmers are giving up these varieties.

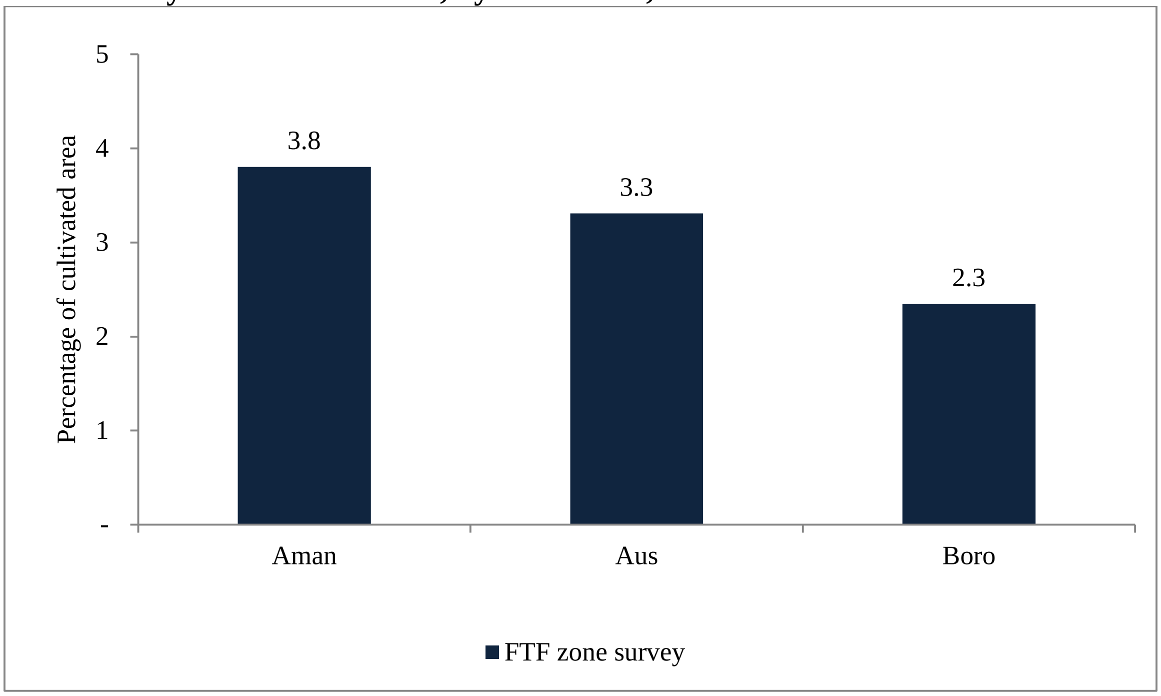
## 5.2 Usage of Stress-Tolerant Rice Varieties by Number of Rice Farmers in the FTF Zone

Since the FTF zone level survey is statistically representative of all rice farmers in the FTF zone, it is possible to estimate the number of rice farmers who used stress-tolerant rice varieties harvested in 2013. According to the 2011 Population and Housing Census conducted by the Bangladesh Bureau of Statistics, there are 6,277,486 rural households in 120 FTF zone upazilas in 20 FTF districts. IFPRI-PRSSP conducted the 2011-2012 Bangladesh Integrated Household Survey (BIHS), which is a nationally representative survey of rural Bangladesh as well as statistically representative of the FTF zone of influence. From the BIHS dataset, we have calculated that 51.9 percent of all households in the FTF zone cultivated rice in 2011. Therefore, the total number of rice farm households in the FTF zone is 3,258,015 (that is, 6,277,486 x 0.519], of which 8.8 percent or 286,705 households have grown at least one stress-tolerant rice variety in 2013.

## 5.3 Area Covered by the Stress-Tolerant Rice Varieties

In terms of acreage, the surveys revealed that the coverage of area under stress-tolerant varieties promoted by research institutes is very low. As Table 5.4 shows, only 3.29 percent of the FTF-zone's area under rice is cropped with these varieties. According to the Bangladesh Bureau of Statistics, 2,794,571 hectares were under rice cultivation in the 20 FTF districts in 2012/13. Therefore, the area coverage of stress-tolerant rice varieties is estimated at 91,914 hectares (that is, 2,794,571 x 0.0329) in the FTF zone of influence. Figure 5.3 shows the percentage of rice area under any stress-tolerant rice variety promoted by the research institutions in the three rice seasons—aus, aman, and boro.

**Figure 5.3 Percentage of rice area under any of the stress-tolerant rice varieties promoted by research institutes, by rice season, 2013**



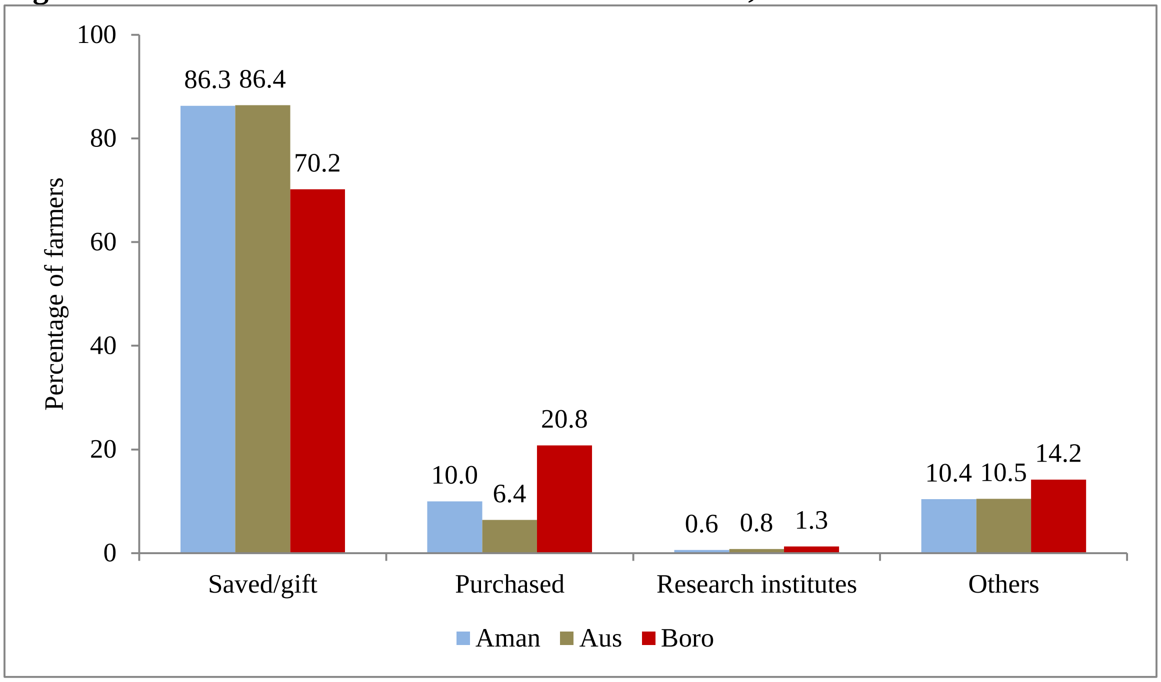

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

### 5.4 Patterns of Seed Use

The survey showed that 91 percent of the rice farmers in the FTF survey sample make their own seedbed prior to transplantation of the paddy seedlings. In doing so, the use of saved seeds from previous harvest predominates for the summer and monsoon crops of aus and aman. For the dry season boro crop, a lower percentage of farmers use saved seeds and a higher percentage of farmers use purchased seed compared to farmers growing aus and aman crops (Figure 5.4).

Table 5.5 provides survey results on seed rates for preparing seed bed for top 10 popular rice varieties, and prices of seeds. Hybrid rice requires a substantially lower quantity of seed per-hectare compared to its inbred (HYV) rice but the price of hybrid seeds is much higher than HYV seeds. The seed rate for hybrid variety Hira is about 41.7 kg/ha. Hira is grown mostly in the boro season. The seed rate ranges from 59 to 73 kilograms per hectare for inbreds (HYVs) in aman season, and from 59 to 76 kilograms per hectare for inbreds in boro season.

**Figure 5.4 Source of seeds for farmers in the FTF zone, 2012**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

# 6. THE DETERMINANTS OF FARMERS' ADOPTION AND DURATION OF FARM TECHNOLOGIES

This section presents an analysis of adoption, retention, and diffusion of both (a) the urea deep placement (Guti urea) technology and (b) a set of modern paddy varieties promoted by agricultural research institutes. It presents the cohort analysis followed by the econometric analysis[4] of each technology.

It is important to mention at the outset that, while agricultural research institutes have promoted many varieties within the FTF zone as reported in the previous section, the analysis of adoption, retention, and diffusion that follows focuses on the top five varieties—BR 41, BR 47, BR 49, BR 50, and BINA 7— used by sample farmers.

## 6.1 Cohort Analysis and Survivor Functions of Usage of the Guti Urea Technology

Table 6.1 presents the results of cohort analysis of Guti urea usage for the FTF survey sample. The key results are as follows:

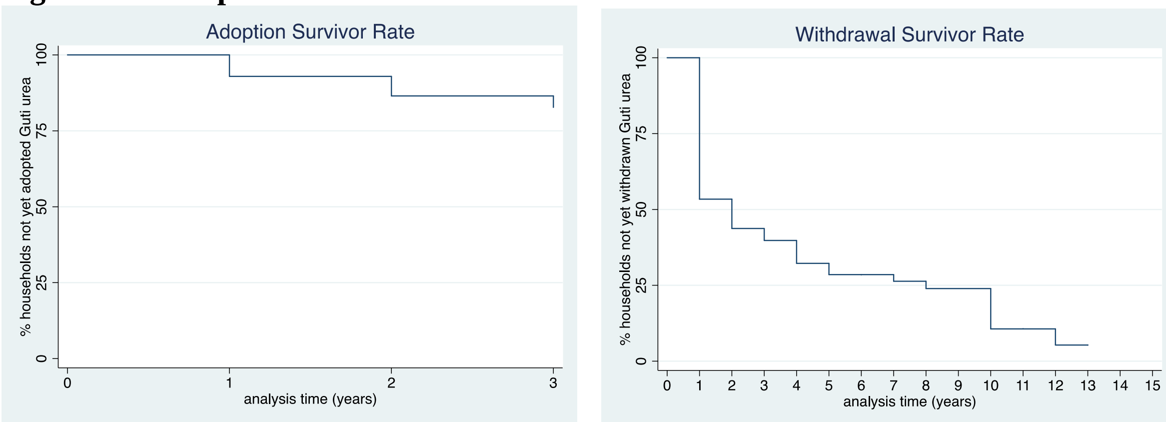
Farmers dropped the Guti urea technology very rapidly. More specifically, about half of the farmers who had used the technology dropped it within one year. This is not a promising result, as it seems that the technology's benefits (for example, higher yields and more efficient use of fertilizer) do not outweigh its costs or the cultural-practice changes that farmers need to make in order to adopt it. An encouraging sign about this result, however, is that in 2013 the dropout rate decreased significantly to 36 percent, which might imply that farmers have grown more willing to continue using the technology beyond the first year. However, a dropout rate of 36 percent is still very high.

Just more than 20 percent of FTF sample farmers used the Guti urea technology at some point during the four-year observation period (2010–2013). However, the diffusion was gradual. The left-side chart of Figure 6.1 shows the survivor function for the Guti urea adoption decision within the FTF zone, which can be interpreted as the share of households that *have not* used Guti urea at a given time (*t*). This graph shows that farmers began using Guti urea soon after being exposed to the "possibility" of adoption, but the shape of the survival function might suggest high entry costs of adoption because the share of households not adopting decreased slowly.

Once farmers use Guti urea, they seem to withdraw rapidly, which confirms the results of the cohort analysis. The right-side chart of Figure 6.1 presents the survival function of the withdrawal decision over the 15-year observation period (1998-2013); it shows that the first signs of desertion occur immediately after the household has used the new technology. By the fifth year, 70 percent of the adopters have stopped using Guti urea and, at the end of the observation period, only one-tenth of the users could be classified as uninterrupted adopters.

[4] Appendix B explains the economic modeling and methodology that support the econometric analysis of the adoption of new farm technologies using survival analysis.

**Figures 6.1 Adoption and withdrawal survivor rates of Guti urea**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

## 6.2 Determinants of Time-to-Adoption of Guti Urea and Duration

Table 6.2 shows the results of the two estimated regression models explaining time-to-adoption and duration (or, time-to-withdrawal), which could be termed as "adoption spell" and "withdrawal spell," based on terminology in the existing literature. We use an Accelerated Failure Time (AFT) transformation of the proportional hazards model; the AFT coefficients reflect the acceleration and deceleration effect on time-to-adoption and time-to-withdrawal, which is an analogous interpretation of common regression models. Negative coefficients imply higher probability of adoption (or withdrawal) because they suggest that the variable they represent reduces the pre-adoption (pre-withdrawal) spell. We discuss the statistically significant results below and, in some cases, highlight the variables we expected to be significant that, in reality, were not. The likelihood ratio test of significance of the regressions (chi-squared statistics) and the *p* values associated with these statistics show the overall significance of both the adoption and withdrawal spells models to be significant at the 1 percent level.

Several results are remarkable for the determinants of time-to-adoption.

1. Farm size (determined by the amount of operated land) plays a significant role in determining adoption of Guti urea; larger operated land significantly shortens time to adoption. This is a fairly predictable result because farmers with more operated land tend to have more intensive productive systems and are therefore less risk-averse and more willing to try new farm technologies.
2. Education of the head of the household reduces the time-to-adoption. This is an important result demonstrating the positive influence of education in technology adoption rates. It is also an expected result based on the economic literature.
3. The number of adults in the household also reduces time-to-adoption of the Guti urea technology. Guti urea is a very labor-demanding technology, so more family labor stock eases its implementation and reduces the constraint associated with hiring more farm labor.
4. Female-headed households were found to be slower in adopting Guti urea, which is disturbing because one of the objectives of the program promoting Guti urea is to involve rural women into the adoption of new farm technologies.

Several results are salient for the determinants of Guti urea technology duration.

1. Farm size was *not* found to be a significant determinant of duration of use. This is an important finding when considered against the literature, which states a controversy (as noted above) about whether farmers with minimal land can adopt modern technologies.
2. Analogous to our finding that education reduces the time-to-adoption, we found that education also lengthens the duration of Guti urea technology use. Access to credit plays an important role in extending duration of Guti urea use.
3. Access to credit can relax the cash constraint, which enables farmers to hire more labor—a necessary expense for adopting the technology.
4. Household characteristics related to stability lengthen duration of use. Variables such as age and marital status of the household head lead to longer Guti urea use.

### 6.3 Cohort Analysis and Survivor Functions of Stress-Tolerant Rice Varieties Promoted by Research Institutes

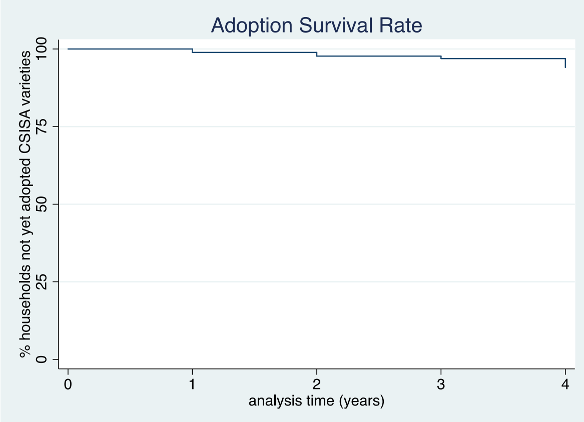
Table 6.3 presents the cohort analysis results of stress-tolerant rice varieties for the FTF survey sample. The main results are as follows:

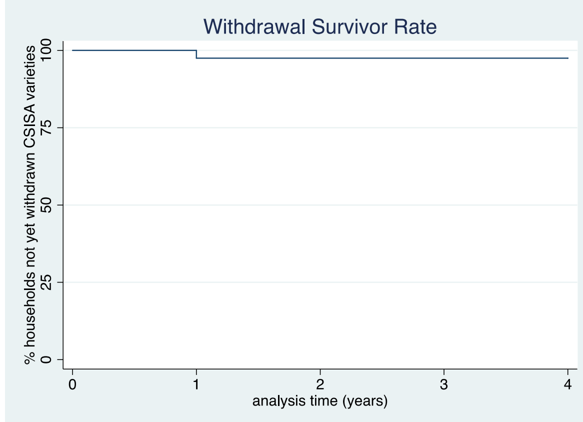
First, farmers who used the stress-tolerant rice varieties once, continue on as consistent users of such varieties. In the FTF zone of influence, the average annual retention rate of the new varieties is 98 percent, which implies that once farmers adopt the new varieties they continue to cultivate the varieties for a long period of time. This is a very encouraging result for the research institutes because it suggests a low dropout rate among farmers who adopt the new varieties. Second, 7.3 percent of farmers included in the FTF sample used the stress-tolerant rice varieties at some point during the five-year observation period (2009–2013). The diffusion was very slow, however. The left-side chart of Figure 6.2 shows the survivor function for the stress-tolerant rice varieties adoption decision within the FTF zone; it can be interpreted as the share of households that have not used any of the stress-tolerant varieties at a given time (*t*). This graph shows that farmers began using the stress-tolerant varieties soon after being exposed to the "possibility" of adoption, but the shape of the survival function shows that this process has been quite slow. That result is to be expected when analyzing the adoption of new/improved crop varieties in developing countries.

Interestingly, once farmers use the stress-tolerant rice varieties, they continue using the new technology and do not withdraw rapidly. There is minimal evidence of dropout of these varieties, which supports the results of the cohort analysis.

The right-side chart of Figure 6.2 shows the survival function of the withdrawal decision, which demonstrates that there is hardly any desertion occurring after adoption of the stress-tolerant rice varieties. By the fourth year of use, more than 95 percent of the users have remained as adopters of the stress-tolerant varieties uninterruptedly.

**Figures 6.2 Adoption and withdrawal survivor rates of stress-tolerant rice varieties**




**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.

## 6.4 Determinants of Time-to-Adoption of the Stress-Tolerant Rice Varieties

Table 6.4 shows the results of the two regression models explaining time-to-adoption and duration (time-to-withdrawal) models. We discuss the statistically significant results below and highlight the variables we had expected to be significant that, in reality, were not. The likelihood ratio test of significance of the regressions (chi-squared statistics) and the *p* values associated with these statistics show the overall significance of both the adoption and withdrawal spell models to be significant at the 1 percent level.

Several results are noticeable for the determinants of time-to-adoption.

1. Similar to our results regarding Guti urea, farm size (determined by operated land) plays a significant role in determining adoption of the stress-tolerant rice varieties promoted by research institutes in the FTF zone of influence; larger operated land significantly shortens the time to adoption. This result is to be expected because farmers with more operated land tend to have more intensive productive systems and are therefore less risk-averse and more willing to try new farm technologies.
2. Again similar to the analysis of Guti urea results, education of the head of the household reduces the time-to-adoption of the stress-tolerant rice varieties.
3. Interestingly, female-headed households are *more likely* to adopt the stress-tolerant rice varieties than other sample households.

The main findings for determinants to duration of the stress-tolerant rice varieties use are presented below.

1. The size of total operated land has a positive effect on duration of use of the stress-tolerant varieties; it increases duration.
2. Having access to irrigation increases duration of time using the stress-tolerant varieties. Similar to total operated land, this result is related to production system intensification.

3. Being married also has a positive effect on the duration of use of these varieties. This result is related to life cycle household stability, as discussed previously for Guti urea technology.

# 7. SUMMARY AND CONCLUSIONS

Using data collected through a survey of rice-farm households, the IFPRI-PRSSP study analyzed two agricultural technologies promoted in USAID's Feed the Future (FTF) zone of influence in the south and southwest regions of Bangladesh. The first technology assessed is urea deep placement—a relatively new fertilizer technology frequently called "Guti urea". The second technology assessed is a set of modern stress-tolerant paddy varieties. The survey conducted in the FTF zone of influence saw different results.

## Guti Urea: Findings and Analysis

The IFPRI-PRSSP survey, which represented all rice farmers in 120 upazilas that comprise the FTF zone of influence in Bangladesh, found that 10.8 percent of all rice farmers used Guti urea for crops harvested in 2013. Overall, the percentage of farmers who used Guti urea was seen to increase when farm size increased. In total, 4.8 percent of rice farm area under cultivation in the FTF zone survey sample was under Guti urea application. Farmers used 43 percent less Guti than prilled urea (because less Guti urea is required for cultivation than prilled) for cultivating boro rice. Farmers who exclusively used Guti urea for boro rice cultivation had 13 percent higher paddy yields than farmers who exclusively used prilled urea. If paddy yields are high with relatively low amounts of Guti urea application, why don't more farmers in the FTF zone of influence use Guti urea for crop cultivation? Farmers in the survey cited high labor requirements and low availability as the dominant impediments to greater Guti urea use. Ensuring enough supply of Guti urea is therefore a prerequisite for its adoption by farmers.

The rates of adoption of Guti urea are much lower for pure tenant farmers—that is, farmers who do not own any cultivable land—than for (a) those who cultivate their own land and (b) those who cultivate their own land in addition to taking in land as sharecroppers and/or leaseholders (mixed tenants). About one-fifth of all rice-farm households in the FTF zone are pure tenants that do not own the land they work. Therefore, they have insecure, prohibitive, and unstable access to land through sharecropping or land-leasing arrangements, which acts as a deterrent for technology adoption. These farmers must pay rent for the land they cultivate, which makes farming a low-profit enterprise for them.

## Modern, Stress-Tolerant Rice Varieties: Findings and Analysis

In the FTF zone of influence, less than one-tenth (8.8 percent) of the farmers grew at least one of the stress-tolerant rice varieties.

Across farm size groups, adoption of the stress-tolerant rice varieties is higher among the medium and large farms than among marginal and small farms. A plausible explanation for the relatively low adoption of the stress-tolerant rice varieties could be that small and marginal farmers are risk-averse given their lack of a diversified portfolio, which severely constrains their ability to offset any crop loss. It is understandable that these poor farmers prefer to stick to time-tested varieties with assured yields rather than experiment with new ones.

In terms of acreage, the surveys revealed that the coverage of area under stress-tolerant varieties is very low, only about 3 percent of the FTF-zone's area under rice is cropped with these varieties.

**Synthesis and Conclusions**

Although the analyses of adoption and diffusion of the two technologies show very different results, overarching conclusions emerge. First, disregarding the type of technology, education plays a key role in new farm-technology adoption and diffusion. This is evidenced by the rate at which educated heads-of-household tended to adopt new technologies in comparison to less-educated heads-of-household. Those with more education also continued using the new technologies for longer periods of time.

Second, new farm technologies have higher probability of being adopted if farmers experience minimal changes in their production systems as a result of adoption. It is easier to change a paddy variety than it is to adopt a new fertilizer technology, which demands major adjustments in labor use at the farm level.

Third, projects and programs that promote new farm technologies should be strongly encouraged to monitor retention of those technologies. The results of this IFPRI-PRSSP study show that a new technology can have a massive dropout rate within one year of adoption, which is a clear sign that farmers are facing challenges with it.

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# APPENDIX A: TABLES

**Table 3.1 Characteristics of survey households by farm size groups: Feed the Future zone**

| Item | Marginal | Small | Medium | Large | All |
|---|---|---|---|---|---|
| Household size (person) | 4.6 | 4.8 | 5.3 | 5.6 | 5.0 |
| Primary-school-age children (6-10 years) who do not go to school (percent) | 7.3 | 7.9 | 8.4 | 7.7 | 7.8 |
| Secondary-school-age children (11-18 years) who do not go to school (percent) | 28.5 | 23.6 | 27.4 | 20.8 | 25.0 |
| Years of schooling, male household head | 3.3 | 4.0 | 4.4 | 4.9 | 4.0 |
| Years of schooling, wife of household head | 3.2 | 3.8 | 4.2 | 4.3 | 3.8 |
| Years of schooling of adult male aged 15 and above | 4.6 | 5.3 | 5.8 | 6.3 | 5.5 |
| Years of schooling of adult female aged 15 and above | 3.9 | 4.7 | 5.2 | 5.5 | 4.8 |
| No schooling adult male (percent) | 44.7 | 37.2 | 32.4 | 27.5 | 36.0 |
| No schooling adult female (percent) | 53.0 | 45.0 | 37.0 | 33.0 | 43.0 |
| *Literacy rate For people aged 15 years and over* | | | | | |
| All | 58.9 | 65.6 | 71.4 | 75.3 | 67.2 |
| Male | 62.2 | 67.4 | 72.7 | 76.7 | 69.2 |
| Female | 55.5 | 63.7 | 70.0 | 73.6 | 65.0 |

**Source:** IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

**Table 3.2 Distribution of operated land: Feed the Future zone**

| Group | Average size of operated land | Share of total operated land in each group |
|---|---|---|
| | (decimal/household) | (percent) |
| 1 (lowest) | 15.51 | 0.50 |
| 2 | 27.93 | 0.90 |
| 3 | 36.61 | 1.23 |
| 4 | 46.64 | 1.58 |
| 5 | 56.54 | 2.27 |
| 6 | 64.65 | 1.77 |
| 7 | 71.37 | 1.84 |
| 8 | 80.15 | 2.73 |
| 9 | 91.20 | 2.76 |
| 10 | 100.99 | 3.30 |
| 11 | 112.78 | 3.66 |
| 12 | 127.74 | 4.07 |
| 13 | 142.01 | 4.80 |
| 14 | 161.39 | 5.06 |
| 15 | 183.96 | 5.87 |
| 16 | 208.83 | 6.66 |
| 17 | 241.20 | 7.62 |
| 18 | 285.16 | 9.17 |
| 19 | 365.47 | 11.75 |
| 20 (highest) | 698.02 | 22.45 |
| All households | 155.33 | 100.00 |

**Source:** IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

### Table 3.3 Average size of operated land by farm size groups: Feed the Future zone

| Farm size group | Operated land size: Mean | Minimum | Maximum |
|---|---|---|---|
| | | (acres/farm household) | |
| Marginal (>0-<0.5 acre) | 0.31 | 0.01 | 0.50 |
| Small (0.5-1.49 acres) | 0.93 | 0.50 | 1.49 |
| Medium (1.50-2.49 acres) | 1.92 | 1.50 | 2.48 |
| Large (>=2.5 acres) | 4.31 | 2.50 | 20.16 |
| All | 1.55 | 0.01 | 20.16 |

**Source:** IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

### Table 3.4 Land tenure arrangements by farm size groups: Feed the Future zone

| Tenurial arrangement | Farm size groups (operated land): Marginal | Small | Medium | Large | All |
|---|---|---|---|---|---|
| | | | (percent) | | |
| Pure tenant | 33.19 | 19.58 | 14.09 | 13.02 | 20.16 |
| Sharecropping | 69.93 | 61.58 | 53.23 | 48.00 | 61.75 |
| Cash lease | 28.10 | 26.60 | 35.48 | 30.00 | 28.63 |
| Both | 1.96 | 11.82 | 11.29 | 22.00 | 9.62 |
| Own land only | 55.53 | 49.76 | 46.82 | 40.10 | 48.75 |
| Mixed tenant (own land + land taken in) | 11.28 | 30.67 | 39.09 | 46.88 | 31.09 |
| Sharecropping | 76.92 | 65.41 | 56.40 | 51.67 | 60.66 |
| Cash lease | 21.15 | 27.99 | 33.14 | 33.33 | 30.06 |
| Both | 1.92 | 6.60 | 10.47 | 15.00 | 9.28 |

**Source:** IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

## Table 4.1 Usage of Guti urea by farmers in 2013, by farm-size groups

| Crop | Farm-size group: Marginal | Small | Medium | Large | All |
|---|---|---|---|---|---|
| | (percentage of farmers) | | | | |
| Rice | 7.61 | 10.22 | 9.77 | 13.54 | 10.08 |
| All crops | 7.98 | 11.19 | 10.23 | 14.32 | 10.79 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.
Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

## Table 4.2 Information about Guti urea

| Item | Marginal | Small | Medium | Large | All |
|---|---|---|---|---|---|
| | (percent) | | | | |
| Heard about Guti urea | 92.6 | 94.0 | 95.2 | 92.7 | 93.7 |
| **Source of information about Guti urea** | | | | | |
| Discussion with other farmers | 80.4 | 76.0 | 76.6 | 75.8 | 77.1 |
| Fertilizer dealers | 48.1 | 48.8 | 45.4 | 38.5 | 46.4 |
| Television | 35.9 | 42.6 | 48.2 | 42.4 | 42.1 |
| Government extension workers | 27.1 | 35.6 | 42.5 | 43.5 | 36.2 |
| Seeing the neighbors | 27.3 | 24.4 | 23.2 | 23.0 | 24.6 |
| Billboard/signboard | 12.8 | 17.0 | 19.1 | 20.5 | 17.0 |
| Farmers' meeting | 8.8 | 11.1 | 13.4 | 12.4 | 11.2 |
| Guti urea producers | 11.6 | 10.7 | 10.0 | 11.5 | 10.9 |
| Exhibition | 5.8 | 8.9 | 12.9 | 11.5 | 9.4 |
| IFDC/AAPI training center | 4.4 | 7.3 | 8.4 | 15.7 | 8.2 |
| Radio | 5.2 | 7.5 | 8.6 | 6.2 | 7.0 |
| Banner/festoon | 6.2 | 5.6 | 6.7 | 7.6 | 6.3 |
| NGO | 3.8 | 5.5 | 6.7 | 8.7 | 5.9 |
| Wall advertisement | 3.2 | 3.3 | 7.4 | 5.3 | 4.4 |
| Announcement through mike | 3.4 | 3.6 | 3.6 | 2.5 | 3.4 |
| Newspaper | 1.6 | 2.9 | 4.5 | 3.9 | 3.1 |
| Field day | 2.6 | 2.8 | 3.6 | 3.4 | 3.0 |
| Video | 2.0 | 2.8 | 2.4 | 3.7 | 2.7 |
| Handbill from the IFDC staff at mosque | 0.4 | 1.7 | 1.4 | 1.4 | 1.3 |
| Handbill from the IFDC staff at school | 0.6 | 1.2 | 1.7 | 1.7 | 1.2 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the FTF Zone, 2013.
Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

**Table 4.3 Percentage of rice farm area under Guti urea in 2013, by farm-size groups**

| | Farm-size group | | | | |
|---|---|---|---|---|---|
| **Crop** | **Marginal** | **Small** | **Medium** | **Large** | **All** |
| | (percentage of cultivated area) | | | | |
| All rice | 4.5 | 4.9 | 4.5 | 5.5 | 4.8 |
| Aman | 2.6 | 3.2 | 3.2 | 3.3 | 3.1 |
| Aus | 5.1 | 3.5 | 5.6 | 7.4 | 5.1 |
| Boro | 7.5 | 9.2 | 8.6 | 12.8 | 9.2 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.
Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

**Table 4.4 Reasons for not using Guti urea**

| | Farm-size group | | | | |
|---|---|---|---|---|---|
| **Reason** | **Marginal** | **Small** | **Medium** | **Large** | **All** |
| | (percentage of farmers) | | | | |
| Not satisfied with the results from last usage | 1.7 | 2.3 | 3.1 | 3.1 | 2.4 |
| Guti urea was is not easily available | 34.7 | 36.4 | 42.3 | 40.6 | 37.7 |
| Guti urea shop is far away | 17.6 | 15.4 | 17.4 | 20.3 | 17.0 |
| Price of Guti urea is high | 15.5 | 14.4 | 15.3 | 14.4 | 14.8 |
| It needs many laborers to apply Guti urea | 54.2 | 54.4 | 58.5 | 47.5 | 54.0 |
| It is physically inconvenient to apply Guti urea manually | 28.0 | 28.9 | 30.8 | 22.8 | 28.1 |
| Guti urea application needs line-sowing of rice seedlings | 30.7 | 27.8 | 30.8 | 23.9 | 28.4 |
| It is physically inconvenient to apply Guti with applicator | 10.0 | 9.1 | 12.0 | 6.9 | 9.5 |
| Applicator is not easily available | 14.8 | 12.5 | 13.9 | 10.3 | 12.9 |
| Applicator is not affordable | 11.9 | 8.4 | 12.0 | 6.1 | 9.5 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.
Note: Marginal farmers are with landholding below 0.5 acres; small farmers have between 0.5 and 1.49 acres; medium farmers have between 1.50 and 2.49 acres; and large farmers have 2.5 acres or more.

**Table 5.1 Percentage of farmers cultivating top 10 popular rice varieties in FTF zone in 2013**

| Aman | | Aus | | Boro | |
|---|---|---|---|---|---|
| **Rice variety** | **Percentage** | **Rice variety** | **Percentage** | **Rice variety** | **Percentage** |
| Guti shorna | 10.23 | Mala BR-2 | 8.18 | BRRI dhan BR-28 | 39.07 |
| Mukta BR-11 | 9.22 | BRRI dhan BR-28 | 4.60 | BRRI dhan BR-29 | 16.40 |
| Dishari BR-23 | 7.77 | Asha BR-8 | 2.05 | Hira | 9.40 |
| BRRI dhan BR-39 | 5.75 | Guti shorna | 1.53 | Asha BR-8 | 4.30 |
| BRRI dhan BR-33 | 5.58 | Lal shorna | 1.79 | Mini cut | 4.30 |
| Lal shorna | 3.56 | Biplob BR-3 | 1.28 | ***BRRI dhan BR-47*** | ***2.33*** |
| Kiron BR-22 | 2.94 | Niyamot BR-21 | 1.79 | Kajol lata | 1.60 |
| ***BINA- 7*** | ***2.90*** | Jamaibabu | 1.02 | Lal teer | 1.38 |
| Progoti BR-10 | 2.68 | Aloron 1 | 1.02 | Mala BR-2 | 1.17 |
| BRRI dhan BR-30 | 2.64 | BRRI dhan BR-27 | 0.77 | BRRI dhan BR-33 | 1.17 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.
Note: Modern, stress-tolerant rice varieties are in italic and bold.

**Table 5.2 Percentage of farmers started cultivating top 10 popular rice varieties in FTF zone for the first time since 2000**

| **Top 10 rice varieties** | **2009-2013** | **2004-2008** | **2000-2003** |
|---|---|---|---|
| | | (percentage of farmers) | |
| BRRI dhan BR-28 | 5.88 | 8.21 | 6.71 |
| BRRI dhan BR-29 | 1.67 | 3.75 | 3.71 |
| Guti shorna | 5.71 | 2.67 | 1.42 |
| Mukta BR-11 | 2.25 | 2.25 | 2.21 |
| Dishari BR-23 | 2.21 | 2.25 | 1.88 |
| BRRI dhan BR-33 | 2.79 | 1.67 | 0.96 |
| BRRI dhan BR-39 | 3.63 | 1.29 | 0.42 |
| Hira | 1.58 | 2.71 | 1.00 |
| Lal shorna | 1.21 | 0.75 | 1.25 |
| Asha BR-8 | 0.46 | 0.75 | 0.83 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

**Table 5.3 Percentage of farmers that stopped cultivating top 10 rice varieties since 2000**

| Top 10 rice varieties | 2009-2013 | 2004-2008 | 2000-2003 |
|---|---|---|---|
| | | (percentage of farmers) | |
| BRRI dhan BR-28 | 2.03 | 0.51 | 0.72 |
| BRRI dhan BR-29 | 1.66 | 0.80 | 0.51 |
| Guti shorna | 0.51 | 0.58 | 0.36 |
| Mukta BR-11 | 1.95 | 4.34 | 2.03 |
| Dishari BR-23 | 0.29 | 0.29 | - |
| BRRI dhan BR-33 | 0.94 | 0.14 | 0.07 |
| BRRI dhan BR-39 | 0.29 | 0.07 | - |
| Hira | 0.72 | 0.72 | 0.29 |
| Lal shorna | 0.80 | 0.43 | 0.29 |
| Asha BR-8 | 0.65 | 1.59 | 1.16 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013

**Table 5.4 Percentage of FTF zone rice area under cultivation of the stress-tolerant rice varieties promoted by research institutes, 2013**

| Stress-tolerant rice variety | Percentage of FTF rice area |
|---|---|
| BRRI dhan BR-41 (aman) | 0.34 |
| BRRI dhan BR-43 (aus) | 0.01 |
| BRRI dhan BR-44 (aman) | 0.10 |
| BRRI dhan BR-46 (aman) | 0.03 |
| BRRI dhan BR-47 (boro) | 0.35 |
| BRRI dhan BR-48 (aus) | 0.02 |
| BRRI dhan BR-49 (aman) | 0.57 |
| BRRI dhan BR-50 (Banglar moti) (boro) | 0.11 |
| BRRI dhan BR-51 (aman) | 0.16 |
| BRRI dhan BR-52 (aman) | 0.04 |
| BRRI dhan BR-53 (aman) | 0.00 |
| BRRI dhan BR-54 (aman) | 0.04 |
| BRRI dhan BR-55 (boro/aus) | 0.03 |
| BRRI dhan BR-56 (aman) | 0.01 |
| BRRI dhan BR-58 (aman) | 0.00 |
| Bina- 7 (aman) | 1.34 |
| Bina - 8 (boro/aus) | 0.06 |
| Bina - 10 (aman) | 0.04 |
| Bina - 11 (Aus/Aman) | 0.02 |
| Bina - 12 (aman) | 0.02 |
| Total | 3.29 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013

**Table 5.5 Seed rate for preparing seed bed for top 10 popular rice varieties, 2013**

| | Aman | | Boro | |
|---|---|---|---|---|
| **Rice variety** | **Seed rate (kg/ha)** | **Average price of seed used in the seedbed (Tk/kg)** | **Seed rate (kg/ha)** | **Average price of seed used in the seedbed (Tk/kg)** |
| BRRI dhan BR-28 | 69.64 | 32 | 60.69 | 46 |
| BRRI dhan BR-29 | 61.90 | 38 | 69.22 | 33 |
| Mukta BR-11 | 63.84 | 36 | 58.54 | 32 |
| Guti shorna | 59.21 | 27 | 63.43 | 36 |
| Dishari BR-23 | 63.17 | 35 | - | - |
| Hira (hybrid) | - | - | 41.70 | 228 |
| BRRI dhan BR-33 | 74.08 | 28 | 75.72 | 26 |
| BRRI dhan BR-39 | 76.05 | 36 | - | - |
| Kiron BR-22 | 62.59 | 32 | - | - |
| Lal shorna | 72.93 | 37 | - | - |

**Source:** IFPRI Agricultural Technology Adoption in the Feed the Future Zone Survey, 2013.

**Table 6.1 Cohort analysis of retention and drop out of Guti urea technology in the Feed the Future zone from 2010 to 2013**

| **Farmers** | **2010** | **2011** | **2012** | **2013** |
|---|---|---|---|---|
| | | (number) | | |
| Continued | - | 58 | 100 | 157 |
| New | - | 157 | 146 | 102 |
| Dropped out | - | 68 | 115 | 89 |
| Total users | 126 | 215 | 246 | 259 |
| | | (percent) | | |
| Dropout rate | - | 54 | 53 | 36 |
| Retention rate | - | 46 | 47 | 64 |
| Average dropout rate | - | - | - | 48 |
| Average retention rate | - | - | - | 52 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

**Table 6.2 Adoption and Duration analysis of Guti urea in the Feed the Future zone**

| | Adoption | Duration |
|---|---|---|
| Years of education of head of household (HHH) | -0.025*** | 0.018* |
| | (0.007) | (0.010) |
| HHH is female | 0.523 | 8.024 |
| | (0.339) | (515.658) |
| Age of HHH | -0.002 | 0.008** |
| | (0.002) | (0.003) |
| HHH is married | 0.074 | 0.610*** |
| | (0.166) | (0.219) |
| Number of adults (14 to 60 years old) in the household | -0.037* | -0.009 |
| | (0.021) | (0.039) |
| Total owned land in Acres | 0.000 | 0.000 |
| | (0.000) | (0.000) |
| Total operated land in acres | -0.000*** | -0.000 |
| | (0.000) | (0.000) |
| Output price (taka/kg) | -0.004 | 0.006 |
| | (0.009) | (0.009) |
| Households has irrigation system | 0.013 | -0.033 |
| | (0.062) | (0.100) |
| Households has access to credit | -0.095 | 0.274*** |
| | (0.076) | (0.101) |
| Constant | 2.441*** | 0.327 |
| | (0.272) | (0.347) |
| Observations | 6,215 | 586 |
| Number of households | 2,224 | 237 |
| ρ | 1.753 | 1.766 |
| LR $Chi^2$ (8) | 38.36 | 26.01 |
| Prob>$Chi^2$ | 0.000 | 0.004 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.
Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

**Table 6.3 Cohort analysis of retention and drop out of stress-tolerant rice varieties in the Feed the Future zone from 2009 to 2013**

| Farmers | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| | | | (number) | | |
| Continued | - | 39 | 65 | 91 | 105 |
| New | - | 26 | 28 | 18 | 65 |
| Dropped out | - | 1 | 0 | 2 | 4 |
| Total users | 40 | 65 | 93 | 109 | 170 |
| | | | (percent) | | |
| Dropout rate | - | 3 | 0 | 2 | 4 |
| Retention rate | - | 98 | 100 | 98 | 96 |
| Average dropout rate | - | - | - | - | 2 |
| Average retention rate | - | - | - | - | 98 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.

**Table 6.4 Adoption and duration analysis of stress-tolerant rice varieties in the FTF zone**

| | Adoption | Duration |
|---|---|---|
| Years of education of head of household | -0.017* | 0.013 |
| (HHH) | (0.009) | (0.014) |
| HHH is female | -0.418** | 7.637 |
| | (0.199) | (982.276) |
| Age of HHH | -0.002 | 0.004 |
| | (0.003) | (0.004) |
| HHH is married | -0.228 | 0.999*** |
| | (0.234) | (0.265) |
| Number of adults (14 to 60 years old) in the | -0.000 | 0.023 |
| household | (0.029) | (0.064) |
| Total owned land in acres | 0.000 | 0.001 |
| | (0.000) | (0.001) |
| Total operated land in acres | -0.000* | 0.002** |
| | (0.000) | (0.001) |
| Output price (taka/kg) | -0.017*** | 0.020 |
| | (0.006) | (0.015) |
| Seed price (taka/kg) | 0.001 | -0.003 |
| | (0.001) | (0.002) |
| Households has irrigation system | -0.386*** | 0.327* |
| | (0.102) | (0.184) |
| Households has access to credit | -0.073 | 0.119 |
| | (0.097) | (0.154) |
| Constant | 3.458*** | -0.213 |
| | (0.367) | (0.481) |
| Observations | 9,232 | 384 |
| Number of households | 2346 | 132 |
| $\rho$ | 2.332 | 2.107 |
| LR $Chi^2$ (9) | 32.50 | 55.04 |
| Prob>$Chi^2$ | 0.001 | 0.000 |

**Source:** IFPRI-PRSSP Agricultural Technology Adoption Survey in the Feed the Future Zone, 2013.
Note: Standard errors are in parentheses. *** p<0.01, ** p<0.05, * p<0.1

## APPENDIX B:

## THE DETERMINANTS AND EFFECTS OF FARMERS' ADOPTION AND DURATION OF NEW FARM TECHNOLOGIES

### Duration analysis

As explained by Dadi et al (2004), many studies in the economic literature have analyzed the adoption and diffusion of new farm technologies in many developing countries, however, most of these studies have focused on static scenarios and therefore are limited to analyzing adoption rates at specific moments in time, usually through econometric analysis that relies on the use of binary static models such as probit, logit and Heckman models (Waktola, 1980; Ayana, 1985; Kebede *et al.*, 1990; Mekuria, 1996; Yirga *et al.*, 1996; Dadi *et al.*, 2001). These studies do not consider the dynamic process of adoption decisions, therefore they do not consider the effect of changing conditions (time varying variables), and how these conditions affect not just adoption, but also speed of adoption, How fast/slow are farmers adopting new technologies? What are the conditions that make farmers adopt new technologies sooner rather than later?

Speed of adoption and the policy implications of speed are often ignored, yet they can turn out to be very important characteristics when designing policy interventions to help smallholders adopt new technologies. As Dadi et al (2004) points if for example, if it is thought that large farmers are more likely to adopt than small farmers, a program directed towards small farmers may be considered. However, if small farmers lag behind by only a few seasons the difference is not important and there is no good reason to target small farmers since by the time extension officers reach them, most will already have adopted. Furthermore, Dadi et al (2004) shows that speedy adoption can be very important, as Hazell and Anderson (1986) point out, for policy makers who need rapid results in order to justify project funding since, with discounting, production increases in the early years of a project have much greater impact on the rate of return on capital investment than increases in later years. The length of time, or "duration", farmers wait before adopting a new technology may be expected to depend on a number of economic, social and institutional factors, some of which vary with time (for example, the age of the farmer, and input and output prices) and some of which do not (for example, sex of farmer, geographical location, education level).

The objective of this study is to examine the adoption behavior of agricultural technologies over time of smallholder farmers in Bangladesh using duration analysis, a statistical tool which provides numerical and graphical summaries of duration data and allows the researcher to investigate the effects of explanatory variables on the duration of stay of an individual in a given state. Two new technologies are considered, the adoption of a new fertilizer (Guti urea) and the adoption of improved paddy cultivation varieties.

### The Model

#### *Theoretical and general implementation models*

As our focus is an empirical contribution, we do not present a new theoretical model but draw heavily in this sub-section on the conceptual framework laid out in Carletto et al. (1999, 2010). While their work focused on entry in the non-traditional horticulture exports market by adoption of the crops for that market, it is directly relevant to our treatment of adoption of—entry in—and duration in the supermarket channel in the domestic food market. Thus we merely summarize their conceptual model in this subsection.

Carletto et al. specify a farm household model where a household decides the allocation of its land endowment (A) between traditional technology, $A_o$, and non-traditional (modern) technology (new crop variety, new fertilizer, etc), $A_1$. Using the traditional technology choice is perceived as less production-risky but also has a lower expected return compared to the new modern technology choice. However, new technologies can be costly, where entry costs are perceived higher than those of traditional technology choice. With the vector of variable inputs valued at the cost $w_x$, the income per hectare can be written as follows:

For traditional technology (crops),

$$\prod_0(\mathrm{p}_0, \mathrm{w}, \mathrm{z}_0) + \theta_0 \tag{2.1}$$

For modern technology (crops),

$$\prod_1(\mathrm{p}_1, \mathrm{w}, \mathrm{z}_1) + \theta_1 \tag{2.2}$$

With

$$E(\theta_0) = E(\theta_1) = 0, \sum(\theta_0, \theta_1) = (\sigma_0^2, \sigma_1^2, \rho_{01}\sigma_0\sigma_1) \tag{2.3}$$

where

(1) $p_o$ and $p_1$, are the expected crop prices using the traditional and modern technologies respectively;
(2) $\Pi_0$ and $\Pi_1$ are the expected incomes per hectare of the crops sold;
(3) $\Sigma$ is the variance-covariance matrix of the risk terms $\theta_0$ and $\theta_1$; and
(4) $z_0$ and $z_l$ household assets that affect expected income.

If the household decides to allocate land using the new modern technology ($A_1$ > 0), then the household's total income is

$$Y = (\Pi_0 + \theta_0)A_0 + (\Pi_1 + \theta_1)A_1 + T - c_1, \tag{2.4}$$

where

(1) $c_1$ is the new technology fixed entry costs; and
(2) T is other sources of income.

Assuming that the household is risk averse, it will decide to adopt the new technology when the change in utility due to adoption ($\Delta U_a$) is positive, given an optimal level of allocation land to the new modern technology ($A_1$). That change in utility is determined by the following function:

$$\Delta U_a = \frac{1}{2\phi(\sigma_0^2 + \sigma_1^2 + 2\rho_{01}\sigma_0\sigma_1)}[(\Pi_1 - \Pi_0) - \phi(\rho_{01}\sigma_0\sigma_1 - \sigma_0^2)]^2 - c_1 > 0 \tag{2.5}$$

We now proceed to the specification of the regression model and estimation procedure we use to implement the conceptual model.

We "translate" the theoretical model into an implementation model that has the general form of the equations, and the general categories of variables used in Carletto et al. Following the theoretical model presented we can rewrite equation 2.5, the change in utility from adoption, as follows:

$$\Delta U_a = \Delta U_a(p_0, p_1, w_x, FK, HK, SK, T_o, t_a, V \qquad (2.6)$$

In an analogous way the decision to withdraw is determined by the change in utility that determines withdrawal $\Delta U_w$; initially this change is negative, but may become positive ($\Delta U_w > 0$) and encourage the household to withdraw.

$$\Delta U_w = \Delta U_w(p_0, p_1, w_x, FK, HK, SK, T_a, t_w, V) \qquad (2.7)$$

2.7 is similar to 2.6, with the difference that the earliest time for withdrawal is the time when the household adopts the new technology ($T_a$) and the duration of the withdrawal spell is included as $t_w$.

The equations show that the change in utility from adoption or withdrawal is a function of the following:

1) The exogenous output prices,
2) The exogenous input prices,
3) Household assets: human capital (*HK*); farm capital (*FK*); social capital (*SK*); and community capital (*CK*).
4) Time, which enters the duration equations in several ways:
    a. $T_o$, the potential earliest year for adoption which is either when the new modern technology becomes accessible to the household or when the household is formed;
    b. $t_a$, the household's "time to adoption" which is the time period between $T_o$ and the year the household adopted ($T_a$);
    c. $t_w$, the time from adoption to the time of withdrawal, or the "duration," which is the time as a user of the new technology if they adopted; note that withdrawal may not yet (or never occur).

In most duration models, observations on $t_a$ are of two types:

(1) The household has adopted the new technology, then the value of $t_a$ is directly observed; and
(2) The household has not yet adopted at the time of the survey, so that we have truncated information, since the length of the duration spell ($t_a$) is greater than the length of the observed pre-adoption spell.

We will analyze the "time to adopt" (waiting time of the household before adoption also called in the duration literature the adoption spell) and if the household adopts, the time to withdraw (or duration). Therefore, we manipulate equations 2.6 and 2.7 to express t(a) and t(w) as functions of the explanatory variables in those equations. This will be a prelude to specifying the regression equations in the next subsection. Thus,

$$t_a = t_a(p_0, p_1, w_x, FK, HK, SK, T_o, V) \qquad (2.8)$$

Since we analyze farm duration as user of the new technology (waiting time before withdrawal, also known as the withdrawal spell), it is as follows:

$$t_w = t_w(p_0, p_1, w_x, FK, HK, SK, T_a, V) \qquad (2.9)$$

**The Estimation Procedure**

To estimate the adoption and withdrawal equations, we proceed as follows. Duration models are based on the implementation of hazard rates which are used to analyze decisions over time. The specification of the hazard rate can be done using both parametric and non-parametric methods. Our estimation is performed using Maximum Likelihood. We chose a parametric approach using a Weibull distribution. Drawing on Carletto et al. (2010) we specify the hazard function as follows:

$$h(t) = \lambda(x)^{\rho} \rho t^{\rho-1} \qquad (4.1)$$

where

$$\lambda(x) = e^{-\beta' x} \qquad (4.2)$$

(1) $\lambda$ is the scale parameter, a function of the vector of covariates (x), and
(2) $\rho$ is the shape parameter, which captures the monotonic time dependency of the event.

We use the Accelerated Failure Time (AFT) transformation of the proportional hazards model, as it yields easier results for interpretation. The AFT coefficients reflect the acceleration and deceleration effect on time-to-adoption and time-to-withdrawal, which is an analogous interpretation of common regression models. The AFT model can be written form as follows:

$$\log(t) = \beta' X + \sigma\varepsilon, \qquad (4.4)$$

where

(1) t is a non-negative random variable denoting the time of the event (adoption or withdrawal),
(2) X is the vector of explanatory variables,
(3) $\beta$ is the vector of coefficients,
(4) $\varepsilon$ is the error term[5],

$\sigma$ is a scalar that is equivalent to the inverse of the shape parameter ($\sigma=1/\rho$).

[5] The error term, in the case of a Weibull hazard function, follows an extreme value distribution.