The Division of Labor and Agricultural Innovation in Bangladesh: Dimensions of Gender

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Acronyms and Abbreviations

DAE	Department of Agricultural Extension
DAP	Diammonium Phosphate
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
ha	Hectare
IFDC	International Fertilizer Development Center (An International Center for Soil Fertility and Agricultural Development)
ILO	International Labour Office
IRRI	International Rice Research Institute
kg	Kilogram
MOP	Muriate of Potash
mt	Metric Ton
N	Sample Size
SSP	Single Superphosphate
TSP	Triple Superphosphate
UDP	Urea Deep Placement
USAID	United States Agency for International Development
USG	Urea Supergranules

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Executive Summary

Without reliable statistics and a specific gender analysis of socio-economic data, including income and labor force data, it will be difficult to formulate appropriate policies and programs in Bangladesh that address the needs of its economic players, especially those who are disadvantaged, including the income-poor women. Much work remains to document and more fully understand the issues surrounding gender and the division of agricultural labor. Our intention is to make a contribution through an assessment of the division of labor through subnational data from Bangladesh that is based on two methods of rice fertilization — one traditional method and one innovative method.

The most prevalent and traditional method of applying nitrogenous fertilizer to rice is a basal application before transplanting followed by one or more topdressings in the floodwater within 3–4 weeks after transplanting up to near flowering. Numerous research reports, however, have shown that such practices are inefficient, because generally only about one-third of the fertilizer nitrogen (N) is used by plants and the remainder is lost through volatilization, denitrification, runoff and leaching or immobilized in the soil.

An innovative means to reduce N losses and improve fertilizer efficiency is to deep place fertilizer N as urea supergranules (USG) of compacted prilled urea. The basic method of USG application is to place USG by hand between four alternating hills of rice at a depth of 7–10 cm about 3–7 days after transplanting. This method is called urea deep placement (UDP).

It is precisely the form and method of urea application that is of particular interest in this study. Our intention is to evaluate the consequences of agricultural innovation for the division of labor in general and to particularly assess the consequences for women and their distinct labor contributions to all tasks involved in paddy production. We are particularly interested in quantifying the labor contribution of women as unpaid family workers in paddy production.

Methodology

The field research used an approach that compared broadcast urea plots with UDP plots in the Boro season of 2008. The survey instrument contained 35 closed- and open-ended questions on a broad range of social, demographic and economic variables. The questionnaire items were generally gender specific and very specific about the gender of household laborers and the labor and wages of hired labor. The data on labor were collected for nine specific tasks and include land preparation, transplanting, urea application, other fertilizer application, weeding, irrigation, application of crop protection products, harvesting work and post-harvest work. The post-harvest tasks include carrying, threshing, husking, cleaning, drying, parboiling and storage.

The Sample

Information on the number of blocks and households that used UDP technology for the first time in 2008 was collated by the survey staff. A block is the lowest administrative tier for agricultural production. The selection of

households involved a two-stage process. First, 592 blocks with the greatest number of USG users and thus the highest densities of users were chosen. Density was determined by a visual inspection of the distribution of users in each block. Within each high-density sample block, 1.0 percent of the new UDP users in Boro 2008 were interviewed. This resulted in a simple random sample based on the density of UDP users with households as the sampling unit; the final sample consisted of 3,230 households.

Synopsis of Findings

Explanations for labor changes that result from UDP adoption are prominently evident in some tasks including urea application, weeding, irrigation, application of crop protection products, harvesting and carrying and post-harvest work. The UDP urea application increases total labor, because the manual operation of placing the USG at a uniform distance and specified depth takes more time and effort than broadcasting urea. Weeding labor is reduced because the weed population on fields treated with UDP is lower due to the diminished access that weeds have to nitrogen. Increases in irrigation labor in UDP fields are due to the more attention and time needed to keep an adequate depth of water across the fields and through the growing season. Labor increases from applying crop protection products in UDP fields are due to the higher plant material production and higher canopy density that result from improved crop nutrition; more foliage and higher density imply more attraction of insect pests and a better environment for the development of fungal diseases. The increases in labor for harvest and carrying and post-harvest activities are due to paddy yield increases attributable to UDP.

Attributing labor changes in land preparation, other fertilizer application and transplanting to UDP use is more difficult. Land preparation and other fertilizer applications are performed independently of the urea application method used; thus, the significant differences in labor between UDP and broadcast urea seem to be a random response to the interaction of factors other than the urea application method. Attributing the significant differences in transplanting labor to UDP is difficult, because transplanting in rows is a common practice even in fields that will receive broadcast urea and because placing seedlings in rows does not seem to cause appreciable time or effort changes with respect to transplanting seedlings randomly.

Among those households that hired women as laborers for paddy cultivation, the adoption of UDP affected the mean labor days per hectare for weeding, application of crop protection products and harvesting and carrying. The labor of hired women for weeding and harvesting and carrying decreased significantly with UDP. However, the labor of hired women for application of crop protection products increased significantly with UDP adoption.

For household women, the only statistically significant changes that occurred as a result of UDP were increases in their labor for harvesting and carrying and post-harvest tasks. This is the result of the increased paddy yield from UDP compared with that of broadcast urea. Considering the labor of all women for all tasks, the data in Table 4 indicate that their workload significantly decreases for weeding and significantly increases for application of crop protection products and post-harvest tasks with the adoption of UDP.

The adoption of UDP significantly decreases the use of hired men as laborers for the tasks of land preparation, transplanting, weeding and irrigation with statistical significance. In contrast, the use of hired men as laborers for the tasks of urea application, application of other fertilizers, application of crop protection products and harvesting and carrying increases with statistical significance.

With the exception of labor for weeding, the adoption of UDP significantly increases the mean labor days per hectare for the tasks of land preparation, transplanting, urea application, other fertilizer application, irrigation, application of crop protection products, harvesting and carrying and post-harvest tasks performed by household men.

Considering the labor of all men for all tasks, with the exception of labor for weeding, the adoption of UDP significantly increases the mean labor days per hectare for land preparation, transplanting, urea application, other fertilizer application, irrigation, application of crop protection products, harvesting and carrying, and post-harvest activities.

The percentage of labor days indicates a heavy concentration of labor of hired and household women in post-harvest activities. More than 85.0 percent of the days worked by women in the rice season were post harvest. The distribution of the labor of men across the tasks of paddy production is not concentrated in one task but in several tasks. Hired men mainly work transplanting, weeding and harvesting and carrying (~15.0 percent to 31.0 percent of labor days). In contrast, household men work close to an even percentage of days across all tasks, excluding application of crop production products, which generally demands little attention compared with other tasks in paddy production.

For all labor from all sources, the data show that the practice of UDP is clearly more labor intensive than the practice of broadcasting urea. There is a statistically significant increase in total labor for each task — land preparation, transplanting, urea application, other fertilizer application, irrigation, application of crop protection products, harvesting and carrying and post-harvest tasks.

Weeding is an exception. With weeding, the labor demanded by UDP decreased significantly to half of the labor demanded by broadcast urea. This labor reduction occurred for hired women and both hired and household men. There are two reasons for less weeding in UDP paddy fields. First, the USG is placed in the soil well below the weed roots, and the weeds are more deprived of nutrients and do not flourish well. Second, paddy fertilized with USG forms a canopy of foliage sooner than broadcast paddy and thus shadows the soil so that weeds are more deprived of sunlight and growth is slowed.

A subset of data (14 percent of all data) containing households where hired men and hired women work in the same tasks suggests that UDP introduction to paddy production in Bangladesh contributes to wage equity between men and women. The method of urea application has a significant effect on the distribution of the percentage of women across the three “Wages for Women” categories. The percentage of women who receive less wages than men is 3.62 percent and significantly lower in households where UDP is used. The percentage of women receiving wages equal to men is 6.48 percent and significantly higher in households where UDP is adopted. The substantial increase in paddy yields that result from UDP creates a significantly higher demand for women labor in post-harvest activities. The increased demand for the labor of women results in higher wage compensation for them.

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Introduction

We took our cue for this research from the International Labour Office (ILO) publication entitled "Measuring Gender Dimensions of the World of Work in Bangladesh." It states: "Despite the overall progress made in narrowing gender gaps, women's position in the world of work remains unequal to that of men. Women in Bangladesh are considered as minor players in the economy and secondary participants in the labor market, largely because of the traditional views still held by some sections of the society on the role of women. However, a substantial number of women do work in various categories of employment in both informal and formal economy, though many work as unpaid family workers. Given the above situation, it is assumed that much of the work carried out by women in Bangladesh has either been largely underestimated or simply gone unaccounted for in national statistics, particularly in the collection and analysis of labor force and household data. Without reliable statistics and a specific gender analysis of socio-economic data, including income and labor force data, it will be difficult to formulate appropriate policies and programs that address the needs of its economic players, especially those who are disadvantaged, including the income-poor women" (ILO, 2006).

This perspective is reinforced by the work of the Food and Agriculture Organization of the United Nations (FAO), which gives the following instructive and guiding statement on the importance of subnational data.

"Clearly, many of the agencies producing, using and disseminating such information are those that are most likely to examine issues relating to global development; these agencies may have little interest in disaggregating data available at the subnational level. Thus, important rural/urban, gender, age and other differentials at the subnational level are overlooked in research and evaluation. This makes it difficult for issues of social equity and the specific needs of male and female agricultural producers to be adequately addressed. With new challenges arising from political and economic liberalization processes, it will be of the utmost importance to make statistics available to a wider variety of users. This greater availability of data will help to empower rural women and men through better knowledge, representation of their interests, and more opportunities for collective action for development" (FAO, 1999a).

FAO also says, "The division of labor between genders still remains poorly understood. This is because much of women's work in crop production consists of unpaid labor in fields that produce for the household rather than the market. As a result, women's work goes unrecorded in statistics. Because of this scarcity or, in most cases, sheer lack of available information, there has been little effective recognition of women's labor in agriculture. But gender-disaggregated data is needed to help technicians, planners and policy makers identify the role differences in food and cash crop production as well as men's and women's different managerial and financial control over the production, storage and marketing of agricultural products. Only by the collection and analysis of such gender disaggregated data will development strategies target women as active and equal partners in agricultural development" (FAO, "Gender and Food Security: Division of Labor").

As FAO notes further, "New data on women gathered at subnational level therefore will provide the kind of information needed to develop gender-sensitive policies, gender-responsive program plans and gender-just distribution of benefits. This will enhance rural women's status by recognizing their value, but more than that for economists it will have a dual impact of facilitating the clear articulation of gender issues and thereby providing the basis for sound remedial policy

and planning initiatives. Such therefore is not only for the sake of women but for the sake of agriculture and food security in the years to come" (FAO, 1997).

Also according to FAO, "In almost all rice growing areas of Asia, men traditionally undertake activities such as land preparation, ploughing, irrigation and field-levelling. Women, on the other hand, are responsible for sowing, transplanting, weeding and crop processing" (FAO, 1997). We intend to offer research that advances beyond the generalization that women are known to produce two-thirds of the world's food. In general, women provide 50–60 percent of the labor input; this increases to 80 percent in paddy and rice production (Commonwealth Secretariat, 2001; FAO, 1999a).

With respect to each of these paddy production tasks, our survey data and research are designed to evaluate the gendered division of labor in rather elaborate and subnational detail. We agree that much work remains to document and more fully understand the issues surrounding gender and the division of agricultural labor. Our intention is to make a contribution through an assessment of the division of labor through subnational data from Bangladesh that is based on two methods of paddy fertilization — one traditional method and one innovative method.

Rice is the staple food for about 144 million people in Bangladesh. It provides nearly 48 percent of rural employment, about two-thirds of total calorie supply and about one-half of the total protein intake of an average person in the country. The rice sector contributes one-half of the agricultural gross domestic product (GDP) and one-sixth of the national income in Bangladesh. Almost all of the 15 million farm families in the country grow rice. Rice is grown on about 10.5 million ha, which has remained almost stable over the past three decades.

According to the International Rice Research Institute (IRRI) Knowledge Bank, about 75 percent of the total cropped area and more than 80 percent of the total irrigated area are planted to rice. Thus, rice plays a vital role in the livelihood of the people of Bangladesh. In 1971, total rice production in Bangladesh was about 10.59 million mt, and the country's population was only about 70.88 million. However, the country is now producing about 25.0 million mt to provide food for 144 million people. This indicates that the growth of rice production was much faster than the growth of population. This increased rice production has been possible largely due to the adoption of modern rice varieties on about 66 percent of the rice land, which contributes to about 73 percent of the country's total rice production.

However, there is no reason to be complacent. The population of Bangladesh is still growing by 2 million every year and may increase by another 30 million over the next 20 years. Thus, Bangladesh will require about 27.26 million mt of rice for the year 2020. During this time, total rice area will also shrink to 10.28 million ha. Rice yield, therefore, needs to be increased from the present 2.74 mt/ha to 3.74 mt/ha (Rice Knowledge Bank, 2009).

The most prevalent and traditional method of applying nitrogenous fertilizer to rice is a basal application with or without incorporation before transplanting followed by one or more topdressings in the floodwater within 3–4 weeks after transplanting up to near flowering. Numerous research reports, however, have shown that such practices are inefficient, because generally only about one-third of the fertilizer nitrogen (N) is used by plants and the remainder is lost through volatilization, denitrification, runoff and leaching or immobilized in the soil.

One means to reduce N losses and improve fertilizer efficiency is to deep place fertilizer N as urea supergranules (USG) of compacted prilled urea that can be produced by a village-level briquette machine. The basic method of USG application is to place the USG by hand between four alternating hills of rice at a depth of 7–10 cm about 3–7 days after transplanting. Urea deep placement (UDP) can improve paddy yield by 0.8–1 mt/ha over traditional methods. In 2008 the practice of UDP was used by about 550,000 households on about 280,000 ha in Bangladesh. In our study, the mean paddy yield per hectare from broadcast urea was 6,512.2 mt/ha and 7,629.1 mt/ha with UDP. This represents a mean increase of 1,116.9 mt/ha, a statistically significant increase of 17.2 percent. Earlier work on the social dimensions of the technology shows that the UDP practice results in benefits that are not agricultural *per se* (Thompson, 2007).

It is precisely the form and method of urea application that is of particular interest in our research. Our intention is to evaluate the consequences of innovative fertilization practices for the division of labor in general and to particularly assess the conse-

quences for women and their distinct labor contributions to all tasks involved in paddy production.

The specific objectives of this study are:

1. To evaluate the effect of UDP adoption, compared with broadcast application of urea, in the distribution of labor in rice production by gender and source (hired or household) at the following scales:
   a. Accumulation of the nine tasks required for rice production and the entire geographical area studied.
   b. Accumulation of the nine tasks in each of the 14 districts surveyed.
   c. Accumulation of the 14 districts in each of the nine tasks.
   d. Each of the nine tasks in each of the 14 districts.
2. To assess the geographical variability of UDP's impact on labor in rice production through the 80 upazilas surveyed in the area, for the key tasks: urea application, weeding and post-harvest activities.
3. To evaluate the effect that UDP adoption, compared with broadcast application of urea, has on paddy yields in the 14 districts surveyed.
4. To evaluate the impact of UDP adoption on the relationship between paddy yields and household women labor.
5. To evaluate the effect that UDP adoption, compared with broadcast application of urea, had on the wage equity by gender in the entire area surveyed.

Methodology

The field research used an approach that compared broadcast urea plots with UDP plots in the Boro season of 2008. Boro rice is transplanted in January–February and harvested in May–June. The survey instrument contained 35 closed- and open-ended questions that sought data on a broad range of household, social, demographic, agronomic, labor and economic variables. The questionnaire items were generally gender specific and very specific about the gender of household laborers and the labor and wages of hired labor. The data on labor were collected for nine specific tasks and include land preparation, transplanting, urea application, other fertilizer application, weeding, irrigation, application of crop protection products, harvesting and post-harvest work. The post-harvest tasks include carrying, threshing, husking, cleaning, drying, parboiling and storage.

The Sample

Information on the number of blocks and households that used UDP technology for the first time in 2008 was collated by the survey staff. A block is the lowest administrative tier for agricultural production. The selection of households involved a two-stage process. First, 592 blocks with the greatest number of USG users and thus the highest densities of users were chosen. Density was determined by a visual inspection of the distribution of users in each block. Within each high-density sample block, 1.0 percent of the new UDP users in Boro 2008 were interviewed. This resulted in a simple random sample based on the density of UDP users with household as the sampling unit (Cochran, 1977). The final sample consisted of 3,230 households in the project upazilas and districts shown in Table 1.

Table 1. Survey Sample by District, Upazila and Block in the 2008 Boro Season

Districts	Number of Upazilas	Number of Blocks	Number of Sample Households
Brahmanbaria	6	28	286
Chandpur	6	33	334
Chittagong	3	16	39
Comilla	12	54	626
Cox's Bazaar	3	8	59
Feni	3	9	106
Hobiganj	3	22	54
Jamalpur	7	71	389
Kishoreganj	10	104	530
Laxmipur	2	10	65
Mymensingh	12	148	402
Netrokona	4	53	112
Noakhali	4	11	71
Sherpur	5	25	157
Total	80	592	3,230

Data Analysis

The impact that UDP adoption had on labor classified by gender and source was evaluated by testing the hypothesis that the number of labor days from the two types of urea application methods differed. The benefit of UDP on paddy yields is shown in Table 2.

Table 2. Paddy Yields by Method of Urea Application and District

District	N		Yield Mean		Yield Difference
	Broadcast	UDP	Broadcast	UDP	UDP - Broadcast
	(kg/ha)				
Brahmanbaria	265	286	7,445.2	8,523.2	1,078.0*
Chandpur	298	334	5,633.7	6,857.4	1,223.7*
Chittagong	32	39	5,580.4	7,452.6	1,872.2*
Comilla	440	627	6,169.7	7,933.0	1,763.3*
Cox's Bazaar	52	59	5,343.3	7,487.1	2,143.8*
Feni	106	106	6,776.4	7,985.4	1,209.0*
Hobiganj	50	54	4,980.3	6,235.8	1,255.5*
Jamalpur	344	388	6,933.0	7,831.4	898.3*
Kishoreganj	457	530	6,587.8	7,489.5	901.7*
Laxmipur	48	65	5,669.4	6,501.4	832.0*
Mymensingh	379	406	7,230.2	7,728.4	498.2*
Netrokona	106	112	5,619.0	7,110.5	1,491.5*
Noakhali	71	71	6,668.8	8,068.1	1,399.3*
Sherpur	123	153	6,420.4	7,479.1	1,058.7*

*Significant difference at 0.05 level.

The hypothesis was tested with analysis of variance following a completely randomized model. The probability distribution of the counts of labor days is quite skewed given the large number of zero values mainly associated with the labor of women in some tasks. To comply with the normal distribution assumption of the analysis of variance, the data were analyzed after a natural logarithmic transformation after adding 2 to every labor day value (Steel et al., 1997) The hypothesis was tested for the aggregated labor across all nine tasks (Table 3), for individual tasks in all districts (Table 5) and for the separate nine tasks in each of the 14 districts (Tables 6 to 14). The relative importance of labor in each task was evaluated by calculating the proportion of labor days worked in each task with respect to the total days worked through the paddy growing season. These proportions are presented as percentages under the percent column on Tables 5–14.

Hypotheses concerning the impact of UDP adoption on wage equity were tested in a subset of households where both women and men worked on the same tasks. This subsample contained 14 percent of the total households surveyed. The first hypothesis, which was about the possible association between wages of women and urea application method, was evaluated with an independent test using the Chi-Square distribution. The second hypothesis about differences between the broadcast and UDP proportions within each category of "Wage of Women" was evaluated using a binomial test (Snedecor and Cochran, 1980). Proportions are expressed as percentages in Table 15.

The relationship between increases in the labor of household women for post-harvest activities and paddy yield increases was studied with a linear regression model without an intercept term, because it was assumed that without an increase in paddy yield, there would not be an increase in the post-harvest labor of household women.

Study Limitations

This study is intended to be a thorough examination of the subnational gender dimensions of the division of labor in reference to paddy production tasks and two methods of paddy fertilization in Bangladesh. It is not intended to be an agronomic or economic evaluation of the methods of fertilization or paddy production.

Paddy Yields

As shown in Table 2, compared with yields from using broadcast urea, the use of UDP resulted in significant paddy yield increases in all the districts

included in the survey. Yield increases attributable to UDP varied widely among upazilas and ranged from approximately 100 kg/ha to about 3.1 mt/ha (Figure 1). The geographical distribution of yield differences due to UDP use is not random; instead, there is a high degree of continuity grouping sets of contiguous upazilas that share similar soil, weather, crop management and socio-economic characteristics. The highest increases in paddy yield from UDP were observed in upazilas located in northern Comilla district, central and southwest Chittagong district and northern Cox's Bazaar district. This top group of upazilas showed paddy yield increases higher than 1.7 mt/ha. The lowest paddy yield increases (of 250 kg/ha or less) were observed in upazilas in southwestern Mymensingh district. The only case with an average decrease in paddy yield after UDP was adopted was in the Muktagachha upazila in western Mymensingh district, which included 13 households. About 77.0 percent of the area surveyed showed paddy yield increases derived from UDP adoption ranging between 1 mt/ha and 1.7 mt/ha. High variability in paddy yields among the sampled 80 upazilas results from the interaction of many factors associated with seed varieties, availability of irrigation, soil characteristics, weather and crop management practices.

Aggregate Labor for All Tasks

We begin the analysis at the most introductory, general and cumulative level by discussing mean labor days per hectare for all agricultural tasks combined and classified by gender and type of laborer.

With the exception of hired men, the data in Table 3 show that each type of laborer, regardless of gender, contributes a significantly greater number of mean labor days for UDP paddy cultivation compared with the traditional practice of broadcasting urea. Based on these data, we may state with confidence that the practice of UDP is more labor intensive than the practice of broadcasting urea.

With the exception of hired men, the data in Table 3 show that the adoption of UDP resulted in statistically significant increases in the mean labor days for all tasks performed by hired women, household women, household men and total mean labor days for each category of labor. The total hired labor reduction with UDP use is mainly a consequence of the significant 11.3 percent reduction in the labor of hired men for weeding. This will be discussed in more detail in Table 5.

These data are informative but make no refined statement on subnational variation by administrative district. As we will show, such variation is substantial, informative and indeed essential to understand gender and the division in paddy production and fertilization practices in Bangladesh. We now focus on a more detailed analysis of total labor for all paddy production tasks and sample districts.

Table 3. Labor Days for All Agricultural Tasks for Broadcast and UDP Paddy by Type of Labor and Gender

Type of Laborer	Type of Urea Application	
	Broadcast N = 2,778	UDP N = 3,227
	(mean labor days/ha)	
Hired women	1.97	2.07*
Household women	13.08	17.58*
Total women	15.05	19.65*
Hired men	86.59	77.92*
Household men	56.03	70.97*
Total men	142.61	148.88*
Total labor	157.67	168.54*

*Significant difference between urea application types at the 0.05 level.

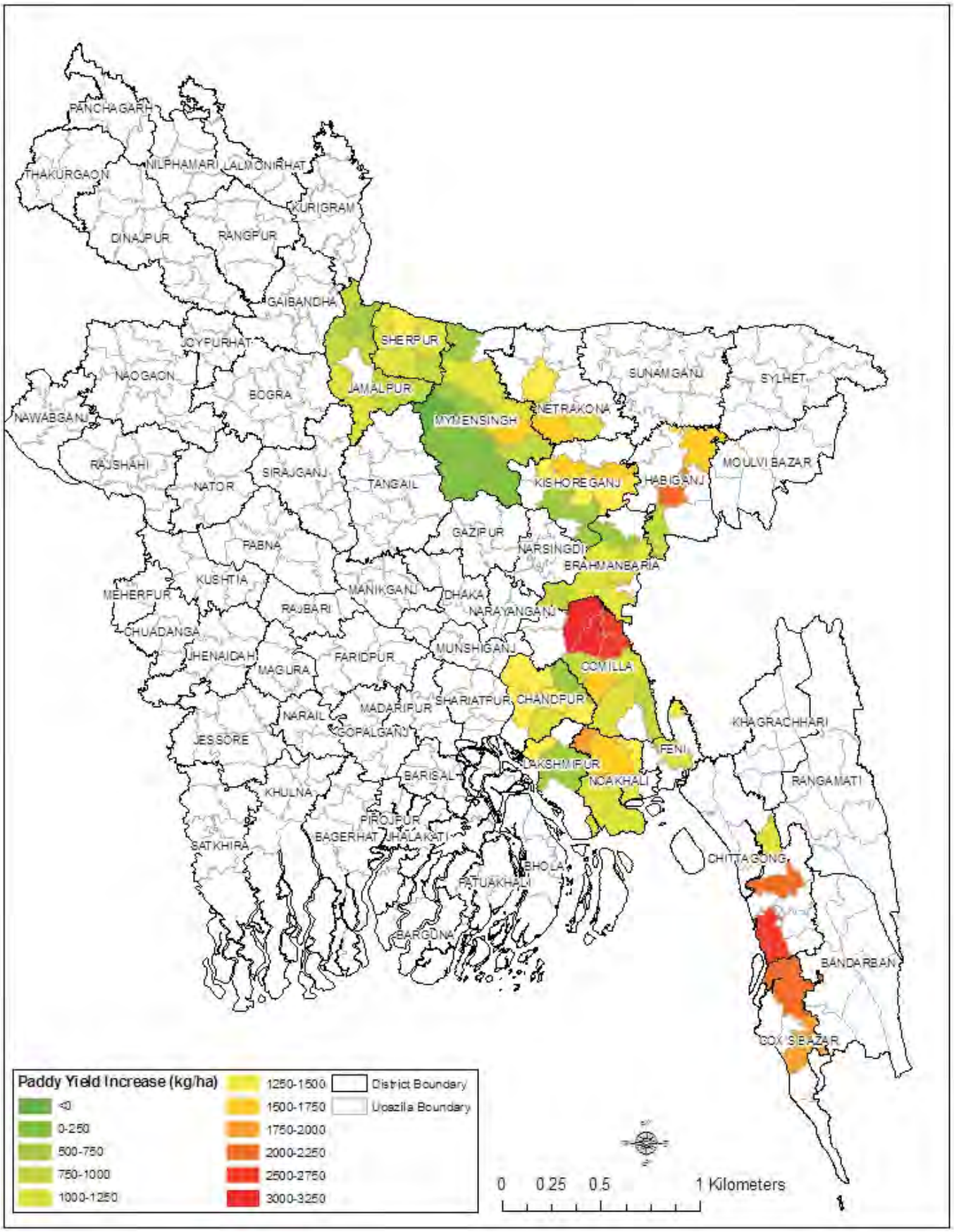

Figure 1. Incremental UDP Paddy Yield by District and Upazila

Labor for All Tasks and Districts

Further analysis in Table 4 includes data on mean labor days per hectare for all agricultural tasks combined for broadcast and UDP paddy by district, source of labor and gender. These data provide a basis to discuss aggregate subnational variation in the division of labor in reference to all agricultural tasks and to the two methods of urea application. We first note that, regardless of the urea application method, the mean labor days per hectare of hired women are minimal in all districts. In Comilla, Cox's Bazaar, Feni and Mymensingh, there was a statistically significant decrease in the mean labor days per hectare that women were hired to work on UDP plots. Only in Kishoreganj, there was a significant increase in the mean days per hectare of hired women compared with broadcast paddy plots.

In sharp contrast to the labor of hired women, the practice of UDP significantly increases the mean labor days per hectare contributed by household women in all districts. The only exception was observed in Chittagong, where that labor decreased but without statistical significance. Thus, we offer with confidence the observation that the innovative agricultural practice

Table 4. Total Labor Days for All Agricultural Tasks for Broadcast and UDP Paddy by District, Type of Labor and Gender

District	Method of Urea Application	N	Mean Labor Days Per Hectare						
			Hired Women	Household Women	Total Women	Hired Men	Household Men	Total Men	Total Labor
Brahmanbaria	Broadcast	266	2.47	13.61*	16.08*	92.75*	81.37	174.12	190.19
	UDP	286	2.72	15.90	18.63	84.52	84.99	169.51	188.14
Chandpur	Broadcast	298	1.19	24.55*	25.73*	141.44*	74.60*	216.03*	241.77*
	UDP	334	1.55	30.07	31.62	119.97	77.00	196.97	228.59
Chittagong	Broadcast	32	5.19	25.93	31.12	89.89	35.71*	125.60*	156.72
	UDP	39	4.62	20.42	25.05	78.17	56.87	135.04	160.08
Comilla	Broadcast	440	0.44	18.28*	18.72*	109.31*	107.59*	216.90*	235.62*
	UDP	626	0.16*	21.13	21.28	89.03	108.61	197.64	218.92
Cox's Bazaar	Broadcast	52	4.51	20.54*	25.05*	57.39	35.46*	92.85*	117.90*
	UDP	59	1.98*	30.60	32.58	61.25	57.81	119.06	151.64
Feni	Broadcast	106	0.50	7.88*	8.38*	47.24	28.08*	75.32*	83.70*
	UDP	106	0.34*	11.03	11.37	48.20	44.07	92.26	103.63
Hobiganj	Broadcast	50	1.65	13.13*	14.78*	61.27	52.62*	113.89*	128.67*
	UDP	54	0.00	25.50	25.50	72.58	77.33	149.91	175.41
Jamalpur	Broadcast	344	0.26	5.54*	5.80*	75.30*	34.71*	110.00	115.80
	UDP	387	0.19	7.82	8.00	62.86	44.87	107.74	115.74
Kishoreganj	Broadcast	459	3.12	12.49*	15.61*	70.44*	45.19*	115.63*	131.24*
	UDP	530	4.64*	17.36	22.00	63.81	62.54	126.34	148.35
Laxmipur	Broadcast	48	7.80	7.98*	15.79*	180.59	19.43*	200.02	215.81
	UDP	65	12.80	13.53	26.34	177.53	35.00	212.53	238.87
Mymensingh	Broadcast	379	4.66	7.96*	12.62*	70.69*	25.87*	96.56*	109.18*
	UDP	401	3.70*	14.98	18.69	68.14	57.29	125.43	144.12
Netrokona	Broadcast	106	0.00	15.65	15.65	74.95*	47.50*	122.44*	138.09*
	UDP	112	0.00	16.80	16.80	59.95	72.44	132.39	149.19
Noakhali	Broadcast	71	0.77	9.42*	10.19*	37.54*	42.91*	80.45*	90.64*
	UDP	71	1.28	13.09	14.37	33.71	68.88	102.59	116.96
Sherpur	Broadcast	127	0.23	4.73*	4.97*	58.16	34.13*	92.29*	97.26*
	UDP	157	0.12	11.75	11.88	61.49	49.43	110.92	122.80

*Significant difference between urea application types at the 0.05 level.

of UDP increases the labor demands on women household members for all tasks associated with paddy cultivation.

Compared with the practice of broadcasting urea, the data in Table 4 on the mean labor days per hectare contributed by hired and household women for all tasks show that their contribution significantly increased with the practice of UDP. In Chittagong, the labor of women decreased with UDP but without statistical significance. In Netrokona, compared with broadcast urea, the labor of household women and total labor of women with UDP increased slightly and without statistical significance.

As a general observation, when compared with the practice of broadcasting urea, the practice of UDP reduces the demand for the labor of hired men. In eight of the 14 sample districts shown in Table 4, the mean labor days per hectare contributed for all agricultural tasks by hired men show a statistically significant decrease. In two districts, labor decreased with UDP but without statistical significance, and in four districts, the hired labor of men increased but again without statistical significance.

For all agricultural tasks and compared with broadcast urea, the mean labor days per hectare contributed by household men increased with statistical significance with UDP in Chandpur, Chittagong, Comilla, Cox's Bazaar, Feni, Hobiganj, Jamalpur Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur. In Brahmanbaria, the labor of household men also increased but without statistical significance.

Compared with broadcast urea, the mean labor days per hectare of total men for all combined agricultural tasks with the practice of UDP increased with statistical significance in Chittagong, Cox's Bazaar, Feni, Hobiganj, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur. In Chandpur and Comilla, the mean labor days per hectare for all men decreased with statistical significance. In Jamalpur and Brahmanbaria, that type of labor decreased without statistical significance.

Compared with broadcast urea, the practice of UDP increased the aggregate use of all labor by men and women for all combined tasks (Table 4) in Cox's Bazaar, Feni, Hobiganj, Kishoreganj, Mymensingh, Netrokona, Noakhali and Sherpur with statistical significance. That labor also increased in Chittagong and Laxmipur but without statistical significance. Curiously, that labor decreased significantly in Chandpur and Comilla. Interestingly, there is virtually no difference in the total labor used in UDP and broadcasting in Jamalpur. We now consider an analysis of the division of labor for each paddy production task and method of urea application.

Labor for Each Agricultural Task and Urea Application Method

The data in Table 5 show mean labor days per hectare by type of urea application, task and gender. Although generally useful and instructive, this is often the type of data in which discussions of gender and the division of agricultural labor cease analysis and offer generalizations without exploring subnational variation (Abdullah and Zeidenstein, 1982). We present and discuss these data as a basis for a more detailed subnational analysis that will follow.

Among those households that hired women as laborers for paddy cultivation, the adoption of UDP affected the mean labor days per hectare for weeding, application of crop protection products and harvesting and carrying. Labor for weeding and harvesting and carrying decreased significantly with UDP but application of crop protection products increased significantly.

For household women, the only statistically significant changes that occurred as a result of UDP were increases in their labor for harvesting and carrying and post-harvest tasks. This is the result of the increased paddy yield from UDP compared with that of broadcast urea. Considering the labor of all women for all tasks, the data in Table 4 indicate that their workload for weeding significantly decreases and significantly increases for the application of crop protection products and post-harvest tasks with the adoption of UDP.

The adoption of UDP significantly decreases the use of hired men as laborers for land preparation, transplanting, weeding and irrigation with statistical significance. In contrast, the use of hired men for urea application, application of other fertilizers, application of crop protection products and harvesting and carrying increases with statistical significance.

Table 5. Mean Labor Days Per Hectare by Type of Urea Application, Task and Gender

Task	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Land preparation	Broadcast	2,771	0.012	0.6	0.113	0.9	0.125	0.8	5.41	6.2*	5.78	10.3*	11.19	7.8*	11.3	7.2*
	UDP	3,230	0.004	0.2	0.004	0.0	0.008	0.0	4.10	5.3	7.43	10.5	11.54	7.8	11.5	6.9
Transplanting	Broadcast	2,776	0.041	2.1	0.009	0.1	0.049	0.3	24.74	28.6*	7.79	13.9*	32.53	22.8*	32.6	20.6*
	UDP	3,226	0.005	0.2	0.014	0.1	0.019	0.1	23.59	30.3	9.36	13.2	32.95	22.1	33.0	19.6
Urea application	Broadcast	2,742	0.000	0.0	0.001	0.0	0.001	0.0	0.33	0.4*	3.33	5.9*	3.66	2.5*	3.7	2.3*
	UDP	3,230	0.000	0.0	0.002	0.0	0.002	0.0	5.13	6.6	5.49	7.7	10.62	7.1	10.6	6.3
Other fertilizer application	Broadcast	2,655	0.004	0.2	0.001	0.0	0.005	0.0	1.10	1.2*	3.11	5.3*	4.21	2.8*	4.2	2.6*
	UDP	2,947	0.006	0.3	0.003	0.0	0.009	0.0	1.26	1.5	4.71	6.1	5.97	3.7	6.0	3.2
Weeding	Broadcast	2,760	0.174	8.8*	0.016	0.1	0.190	1.3*	23.36	26.8*	10.64	18.9*	33.99	23.7*	34.2	21.5*
	UDP	3,147	0.087	4.1	0.012	0.1	0.099	0.5	12.41	15.5	8.37	11.5	20.78	13.6	20.9	12.1
Irrigation	Broadcast	2,166	0.002	0.1	0.021	0.1	0.023	0.1	0.27	0.2*	10.47	14.6*	10.74	5.9*	10.8	5.3*
	UDP	2,506	0.001	0.0	0.007	0.0	0.008	0.0	0.26	0.3	16.85	18.4	17.12	8.9	17.1	7.9
Application of CPPs	Broadcast	1,544	0.000	0.0*	0.000	0.0	0.000	0.0*	0.48	0.3*	1.43	1.4*	1.90	0.7*	1.9	0.7*
	UDP	1,320	0.003	0.1	0.005	0.0	0.008	0.0	0.74	0.4	2.68	1.5	3.42	0.9	3.4	0.8
Harvesting and carrying	Broadcast	2,766	0.060	3.0*	0.054	0.4*	0.115	0.8	23.97	27.6*	7.84	13.9*	31.81	22.2*	31.9	20.2*
	UDP	3,227	0.001	0.1	0.153	0.9	0.154	0.8	23.65	30.4	10.10	14.2	33.76	22.7	33.9	20.1
Post-harvest work	Broadcast	2,769	1.689	85.3	12.913	98.4*	14.602	96.7*	7.58	8.7	8.91	15.9*	16.49	11.5*	31.1	19.7*
	UDP	3,232	1.967	95.1	17.362	98.9	19.328	98.5	7.66	9.9	11.91	16.8	19.57	13.2	38.9	23.1

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.

*Significant difference between urea application types at the 0.05 level.

With the exception of labor for weeding, the adoption of UDP significantly increases the mean labor days per hectare for land preparation, transplanting, urea application, other fertilizer application, irrigation, application of crop protection products, harvesting and carrying and post-harvest tasks performed by household men.

Considering the labor of all men for all tasks, with the exception of labor for weeding, the adoption of UDP significantly increases the mean labor days per hectare for land preparation, transplanting, urea application, other fertilizer application, irrigation, application of crop protection products, harvesting and carrying and post-harvest tasks.

The percentage of labor days indicates a heavy concentration of labor of hired and household women in post-harvest activities. More than 85 percent of the days worked by women in the rice season were occupied in the post harvest. The distribution of the labor of men in paddy production is not concentrated in one task but in several. Hired men mainly work transplanting, weeding and harvesting and carrying (~15.0 percent to 31.0 percent of labor days). In contrast, household men work close to an even percentage of days across all tasks, excluding application of crop production products, which generally demands little attention compared with the other tasks in paddy production.

Finally, in regard to Table 5 and all labor from all sources, the data show that the practice of UDP is clearly more labor intensive than the practice of broadcasting urea. There is a statistically significant increase in total labor for each task — land preparation, transplanting, urea application, other fertilizer application, irrigation, application of crop protection products, harvesting and carrying and post-harvest activities.

Weeding is an exception. With weeding, the labor demanded by UDP decreased significantly to half of the labor demanded by broadcast urea. This labor reduction occurred for hired women and both hired and household men. There are two reasons for less weeding in UDP paddy fields. First, the USG is placed in the soil well below the weed roots, and the weeds are more deprived of nutrients and do not flourish well. Second, paddy fertilized with USG forms a canopy of foliage sooner than broadcast paddy and thus shadows the soil so that weeds are more deprived of sunlight and growth is slowed.

Explanations for labor changes that result from UDP adoption are prominently evident in some tasks including urea application, weeding, irrigation, application of crop protection products, harvesting and carrying and post-harvest work. Urea application with UDP increases total labor because the manual operation of placing the USG at a uniform distance and at a specified depth takes more time and effort than broadcasting urea. Weeding labor is reduced because the weed population on fields treated with UDP is lower due to the diminished access that weeds have to nitrogen. Increases in labor for irrigation in UDP fields are due to the fact that more attention and time are needed to keep an adequate depth of water across the fields and through the growing season; uniform and permanent flooding is critical for UDP to have higher nitrogen supply efficiency than broadcast urea. Labor increases applying crop protection products in UDP fields are due to the higher plant material production and higher canopy density that result from improved crop nutrition; more foliage and higher density imply increased attraction of insect pests and a better environment for development of fungal diseases. The increases in labor for harvest and carrying and post-harvest activities are due to paddy yield increases attributable to UDP.

Attributing labor changes in land preparation, other fertilizer application and transplanting to UDP use is more difficult. Land preparation and other fertilizer application are performed independently of the urea application method used; thus, the significant differences in labor between UDP and broadcast urea seem to be a random response to the interaction of factors other than the urea application method. Attributing the significant differences in labor for transplanting to UDP is difficult because transplanting in rows is a common practice even in fields that will receive broadcast urea; also, placing seedlings in rows does not seem to cause appreciable time or effort changes with respect to transplanting seedlings randomly. We now turn our attention to the most detailed analysis of labor for each paddy production task with respect to district and method of urea application.

Labor for Each Paddy Production Task by District, Urea Application Method and Gender

As suggested by ILO and FAO, our data provide a further and more refined understanding of gender and the division of labor in paddy production in Bangladesh through subnational data. In this section, we discuss mean labor days per hectare for all tasks by district, method of urea application and gender. We will discuss such data for land preparation, transplanting, urea application, other fertilizer application, weeding, irrigation, application of crop protection products, harvesting and post-harvest tasks.

Land Preparation

We begin with Table 6, which shows mean labor days per hectare for land preparation by district, method of urea application, laborer by gender and source of labor (hired or household). It is very evident that hired women and household women make no meaningful contribution to land preparation work. It is further evident that the labor of women for that task is not affected by the adoption of UDP. The few percentages of labor days that are not zero reflect the very low total of days worked by women in land preparation. The employment of hired men for land preparation is broadly and significantly affected by the use of UDP. The mean labor days per hectare contributed by hired men decreased significantly in the districts of Chandpur, Chittagong, Comilla, Feni, Jamalpur, Mymensingh, Netrokona and Noakhali. UDP does not appear to significantly affect the mean labor days per hectare of hired men for land preparation in Brahmanbaria, Cox's Bazaar, Hobiganj, Kishoreganj, Laxmipur and Sherpur.

The data in Table 6 show a dramatic and significant increase in the mean labor days per hectare for land preparation among household men in Chandpur, Chittagong, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur. Adoption of UDP does not appear to significantly affect the mean labor days per hectare of hired men for land preparation in Brahmanbaria and Comilla.

The total labor use for land preparation increased significantly in Brahmanbaria, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur. UDP does not appear to significantly affect the mean labor days per hectare of hired men for land preparation in Chandpur and Chittagong, but the labor days decrease significantly in Comilla as a direct result of reduced hired labor and no significant increase in the labor of household men for land preparation.

These data strongly suggest that the practice of UDP significantly reduces the use of hired men and increases the use of household men for land preparation. UDP shifts the work burden directly to the household members. Considering Bangladesh's inflation rate of about 9.2 percent in 2007 (Asian Development Bank, 2007) and 9.9 percent in 2008 (Bangladesh Bank, 2008), the sample households likely reduced cash expenditures for land preparation and substituted household labor of men. It is also plausible that mechanization and the popularity of power tillers reduced the need for hired labor for land preparation.

Transplanting

As with land preparation, it is very evident that hired women and household women make no meaningful contribution to transplanting. From the data in Table 7, it is further evident that the labor of hired and household women for that task is not significantly affected by the adoption of UDP.

The mean labor days per hectare of hired men for transplanting are significantly affected by the adoption of UDP. This labor decreased significantly in the districts of Chittagong, Comilla, Feni, Jamalpur, Mymensingh, Netrokona, Noakhali and Sherpur. UDP did not significantly affect the labor input of hired men for transplanting in Brahmanbaria, Chandpur, Cox's Bazaar, Hobiganj and Kishoreganj. The only significant increase in hired labor for transplanting was observed in Laxmipur.

The adoption of UDP significantly increased the mean labor days per hectare for transplanting by household men in Chittagong, Cox's Bazaar, Feni, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur. In only one district (Comilla) UDP significantly decreased the mean labor days per hectare of hired men for transplanting. In the districts of Brahmanbaria, Chandpur and Hobiganj, the adoption of UDP had no significant effect on the labor input of household men for transplanting.

Table 7 shows that the total labor of men for transplanting increased significantly in Cox's Bazaar,

Table 6. Mean Labor Days Per Hectare for Land Preparation by District, Method of Urea Application and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	265	0.00	0.0	0.00	0.0	0.00	0.0	4.2	4.5	8.6	10.5	12.8	7.3*	12.8	6.7*
	UDP	286	0.00	0.0	0.03	0.2	0.03	0.2	4.4	5.2	8.9	10.4	13.3	7.8	13.3	7.1
Chandpur	Broadcast	298	0.03	2.1	0.02	0.1	0.04	0.2	5.4	3.8*	6.8	9.1*	12.2	5.6	12.2	5.1
	UDP	334	0.00	0.0	0.01	0.0	0.01	0.0	3.2	2.7	9.3	12.0	12.5	6.3	12.5	5.5
Chittagong	Broadcast	32	0.00	0.0	9.65	37.2	9.65	31.0	17.7	19.7*	5.6	15.6*	23.2	18.5	32.9	21.0
	UDP	39	0.00	0.0	0.00	0.0	0.00	0.0	14.5	18.5	10.2	17.9	24.7	18.3	24.7	15.4
Comilla	Broadcast	440	0.00	0.0	0.00	0.0	0.00	0.0	10.6	9.7*	10.5	9.8	21.2	9.8*	21.2	9.0*
	UDP	627	0.02	14.5	0.00	0.0	0.02	0.1	5.6	6.3	10.4	9.6	15.9	8.1	16.0	7.3
Cox's Bazaar	Broadcast	52	0.00	0.0	0.00	0.0	0.00	0.0	11.1	19.3	6.7	18.9*	17.8	19.2*	17.8	15.1*
	UDP	59	0.00	0.0	0.00	0.0	0.00	0.0	12.0	19.6	11.4	19.7	23.4	19.7	23.4	15.5
Feni	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	4.7	10.0*	3.0	10.8*	7.7	10.3*	7.7	9.2*
	UDP	106	0.00	0.0	0.00	0.0	0.00	0.0	4.1	8.6	4.4	9.9	8.5	9.2	8.5	8.2
Hobiganj	Broadcast	50	0.16	10.0	0.00	0.0	0.16	1.1	5.7	9.4	8.8	16.7*	14.5	12.8*	14.7	11.4*
	UDP	54	0.00	0.0	0.00	0.0	0.00	0.0	6.6	9.0	10.8	14.0	17.3	11.6	17.3	9.9
Jamalpur	Broadcast	344	0.02	8.2	0.00	0.0	0.02	0.4	4.0	5.3*	3.0	8.7*	7.0	6.4*	7.1	6.1*
	UDP	388	0.00	0.0	0.00	0.0	0.00	0.0	2.9	4.6	4.5	10.1	7.4	6.9	7.4	6.4
Kishoreganj	Broadcast	457	0.01	0.3	0.00	0.0	0.01	0.1	2.2	3.0	5.4	11.8*	7.5	6.5*	7.5	5.7*
	UDP	530	0.00	0.0	0.00	0.0	0.00	0.0	2.3	3.7	6.3	10.1	8.6	6.8	8.6	5.8
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	7.4	4.1	0.8	4.1*	8.2	4.1*	8.2	3.8*
	UDP	65	0.00	0.0	0.00	0.0	0.00	0.0	8.5	4.8	3.5	9.9	12.0	5.6	12.0	5.0
Mymensingh	Broadcast	377	0.00	0.0	0.00	0.0	0.00	0.0	4.4	6.2*	3.0	11.4*	7.4	7.6*	7.4	6.7*
	UDP	403	0.00	0.0	0.00	0.0	0.00	0.0	3.3	4.8	5.7	10.1	9.0	7.2	9.0	6.3
Netrokona	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	6.5	8.6*	4.8	10.2*	11.3	9.2*	11.3	8.2*
	UDP	112	0.00	0.0	0.00	0.0	0.00	0.0	4.9	8.2	9.4	12.9	14.3	10.8	14.3	9.6
Noakhali	Broadcast	71	0.00	0.0	0.00	0.0	0.00	0.0	3.5	9.2*	4.2	9.8*	7.6	9.5	7.6	8.4
	UDP	71	0.00	0.0	0.00	0.0	0.00	0.0	1.7	5.2	6.5	9.4	8.2	8.0	8.2	7.0
Sherpur	Broadcast	125	0.04	16.6	0.00	0.0	0.04	0.8	2.6	4.4	2.7	7.8*	5.3	5.7*	5.4	5.4*
	UDP	156	0.00	0.0	0.00	0.0	0.00	0.0	3.0	4.9	3.9	7.9	6.9	6.2	6.9	5.6

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

Table 7. Mean Labor Days Per Hectare for Transplanting by District, Method of Urea Application and Gender

District	Type of Urea	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	265	0.06	2.3	0.00	0.0	0.06	0.3	28.3	30.4	13.0	15.9	41.3	23.6	41.4	21.7
	UDP	286	0.03	1.1	0.06	0.4	0.09	0.5	28.0	33.2	13.7	16.1	41.7	24.6	41.8	22.2
Chandpur	Broadcast	298	0.14	11.7	0.03	0.1	0.17	0.6	33.0	23.3	7.0	9.4	40.0	18.5	40.1	16.6
	UDP	334	0.00	0.0	0.00	0.0	0.00	0.0	32.5	27.1	7.2	9.4	39.7	20.2	39.7	17.4
Chittagong	Broadcast	32	0.00	0.0	0.00	0.0	0.00	0.0	27.5	30.6*	6.7	18.7*	34.2	27.2	34.2	21.8
	UDP	39	0.00	0.0	0.00	0.0	0.00	0.0	23.5	30.1	12.4	21.8	35.9	26.6	35.9	22.4
Comilla	Broadcast	440	0.02	3.6	0.00	0.0	0.02	0.1	31.0	28.3*	14.1	13.1*	45.0	20.8*	45.1	19.1*
	UDP	626	0.01	7.6	0.03	0.2	0.04	0.2	27.7	31.2	11.9	10.9	39.6	20.1	39.7	18.1
Cox's Bazaar	Broadcast	52	0.00	0.0	0.08	0.4	0.08	0.3	21.4	37.3	8.2	23.0*	29.6	31.9*	29.7	25.2*
	UDP	59	0.00	0.0	0.00	0.0	0.00	0.0	21.7	35.4	14.3	24.8	36.0	30.2	36.0	23.7
Feni	Broadcast	105	0.00	0.0	0.00	0.0	0.00	0.0	13.0	27.3*	4.6	16.3*	17.7	23.2*	17.7	20.9*
	UDP	106	0.00	0.0	0.00	0.0	0.00	0.0	10.3	21.4	6.2	14.1	16.5	17.9	16.5	16.0
Hobiganj	Broadcast	50	0.49	30.0	0.00	0.0	0.49	3.3	21.3	34.8	9.2	17.6	30.6	26.8*	31.1	24.1*
	UDP	54	0.00	0.0	0.00	0.0	0.00	0.0	20.6	28.4	11.7	15.1	32.3	21.5	32.3	18.4
Jamalpur	Broadcast	344	0.00	0.0	0.01	0.2	0.01	0.2	24.2	32.1*	7.4	21.3*	31.6	28.7	31.6	27.3
	UDP	387	0.00	0.0	0.00	0.0	0.00	0.0	21.3	33.8	9.6	21.3	30.8	28.6	30.8	26.6
Kishoreganj	Broadcast	459	0.00	0.0	0.00	0.0	0.00	0.0	19.8	28.1	5.3	11.7*	25.1	21.7*	25.1	19.1*
	UDP	532	0.00	0.0	0.01	0.1	0.01	0.1	20.5	32.2	6.2	9.9	26.6	21.1	26.6	18.0
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	38.2	21.2*	0.3	1.4*	38.5	19.3*	38.5	17.9*
	UDP	65	0.00	0.0	0.00	0.0	0.00	0.0	46.9	26.4	1.4	4.1	48.4	22.8	48.4	20.2
Mymensingh	Broadcast	379	0.07	1.4	0.00	0.0	0.07	0.5	22.3	31.6*	3.9	15.1*	26.2	27.2*	26.3	24.1*
	UDP	400	0.00	0.0	0.00	0.0	0.00	0.0	20.3	29.8	10.0	17.4	30.3	24.1	30.3	21.0
Netrokona	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	24.2	32.2*	3.2	6.8*	27.4	22.4*	27.4	19.8*
	UDP	112	0.00	0.0	0.00	0.0	0.00	0.0	18.4	30.7	5.6	7.7	24.0	18.1	24.0	16.1
Noakhali	Broadcast	71	0.00	0.0	0.10	1.1	0.10	1.0	10.7	28.5*	8.9	20.9*	19.7	24.4	19.8	21.8*
	UDP	71	0.00	0.0	0.00	0.0	0.00	0.0	7.4	22.0	11.9	17.3	19.3	18.8	19.3	16.5
Sherpur	Broadcast	127	0.00	0.0	0.00	0.0	0.00	0.0	17.8	30.6	6.9	20.3*	24.7	26.8	24.7	25.4
	UDP	155	0.00	0.0	0.00	0.0	0.00	0.0	16.5	26.5	8.2	16.4	24.7	22.0	24.7	19.9

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

Hobiganj, Kishoreganj, Laxmipur and Mymensingh but decreased significantly in Comilla, Feni and Netrokona. In Brahmanbaria, Chandpur, Chittagong, Jamalpur, Noakhali and Sherpur the practice of UDP did not significantly affect the labor input of men for transplanting.

With the adoption of UDP, the total labor input from all sources for transplanting increased significantly in Cox's Bazaar, Hobiganj, Kishoreganj, Laxmipur and Mymensingh. The new method of urea application did not significantly affect total labor input for transplanting in Brahmanbaria, Chandpur, Chittagong, Jamalpur and Sherpur. Total labor for this task significantly decreased in Comilla, Feni, Netrokona and Noakhali. The recommendation for transplanting seedlings with USG requires careful plant spatial variations and line transplanting. As with land preparation, it is likely that the inflation rate in 2008 prompted reduced cash expenditures for transplanting and substituted household labor of men.

Urea Application

With a minor exception in Jamalpur, the data in Table 8 clearly show that the application of urea for paddy production is not a task performed by hired or household women in the sample districts but rather by hired and household men. In each sample district, the mean labor days per hectare of hired and household men, total labor of men and total labor are significantly greater for UDP than for broadcast urea. There are two exceptions for the labor of household men for urea application in Comilla and Laxmipur, where there is a relatively greater reliance on hired labor for this task. The use of hired labor in these districts is among the highest in the sample. We conclude from these data that the introduction of UDP created new employment opportunities for men but not for women. Those who adopt UDP are well aware that the practice is labor intensive and that the placement of USG requires a measure of training and skill. Reductions in land preparation and transplanting are significant but may not be due to UDP.

Figure 2 shows the geographical distribution of the labor of hired men for urea application as affected by use of UDP. Sets of contiguous upazilas grouped in the same map scale categories (same color on the map) suggest that the similarity of socio-economic factors in the upazila groups reflect similar changes in labor as a result of UDP adoption. The highest increases in the labor of hired men of (nine days/ha or more) occurred in the Barura upazila in Comilla, Raujan in northern Chittagong, Ishwarganj in eastern Mymensingh, Nalitabari in southeastern Sherpur and Parshuram in the northern tip of Feni. These locations account for 4.12 percent of surveyed area. Most of the surveyed upazilas showed increases in the labor of hired men from one day/ha to six days/ha (68.13 percent of surveyed area). Only Sreebardi in central Sherpur district showed decreased or no labor change (1.1 percent of surveyed area) in the hired labor of men for urea application. Most of the upazilas in Comilla, Chittagong and Cox's Bazaar had increases of six or more days per hectare in the labor of hired men for urea application.

Other Fertilizer Application

As shown by the data in Table 9, the labor distribution for the application of other fertilizers is dramatically different than for urea application. Other fertilizers include diammonium phosphate (DAP), single superphosphate (SSP), triple superphosphate (TSP), muriate of potash (MOP), gypsum and zinc. Again, with a minor exception in Laxmipur, the data in Table 9 clearly show that the application of other fertilizers is not a task performed by hired or household women or by hired men in the sample districts. Thus, unlike USG application, the task of applying other fertilizers does not produce employment opportunities since it is performed principally by household men. Particular conditions in the Laxmipur district suggest that this is the only district sampled where this task generates employment for men.

Application of other fertilizer is one of the tasks in which labor changes are not clearly associated with the practice of UDP. We believe that the significant differences in labor among urea application methods across the districts studied are mainly due to factors other than UDP adoption.

Except in Chandpur, Kishoreganj and Noakhali, where the use of the hired labor of men for the application of other fertilizers decreased significantly, the adoption of UDP had no significant effect on the use of labor of hired men for this task. In each sample district, there was a statistical increase in the mean labor days per hectare of household men for the application of other fertilizers. Thus, it is evident that this is virtually an exclusive task of household men. Except in Cox's Bazaar and Noakhali, the total labor

Table 8. Mean Labor Days Per Hectare for Urea Application by District, Method of Urea Application and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	265	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.2*	4.5	5.5*	4.7	2.7*	4.7	2.5*
	UDP	287	0.00	0.0	0.00	0.0	0.00	0.0	3.6	4.2	7.4	8.7	10.9	6.5	10.9	5.8
Chandpur	Broadcast	298	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1*	6.2	8.3*	6.3	2.9*	6.3	2.6*
	UDP	334	0.00	0.0	0.00	0.0	0.00	0.0	2.8	2.3	9.4	12.2	12.2	6.2	12.2	5.3
Chittagong	Broadcast	32	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1*	1.5	4.3*	1.6	1.3*	1.6	1.0*
	UDP	39	0.00	0.0	0.00	0.0	0.00	0.0	7.9	10.1	4.4	7.8	12.3	9.1	12.3	7.7
Comilla	Broadcast	440	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0*	6.0	5.6*	6.0	2.8*	6.0	2.6*
	UDP	624	0.00	0.0	0.00	0.0	0.00	0.0	7.4	8.	3.9	3.5	11.3	5.7	11.3	5.1
Cox's Bazaar	Broadcast	52	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.2*	1.5	4.3*	1.7	1.8*	1.7	1.4*
	UDP	59	0.00	0.0	0.00	0.0	0.00	0.0	6.7	11.0	5.9	10.2	12.6	10.6	12.6	8.3
Feni	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.2*	1.4	4.8*	1.4	1.9*	1.4	1.7*
	UDP	107	0.00	0.0	0.00	0.0	0.00	0.0	7.2	15.2	5.6	12.9	12.9	14.1	12.9	12.5
Hobiganj	Broadcast	50	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.5*	2.8	5.2*	3.1	2.7*	3.1	2.4*
	UDP	55	0.00	0.0	0.00	0.0	0.00	0.0	5.0	7.1	9.4	12.3	14.4	9.8	14.4	8.4
Jamalpur	Broadcast	340	0.00	0.0	0.00	0.0*	0.00	0.0*	0.6	0.8*	2.6	7.3*	3.2	2.9*	3.2	2.7*
	UDP	386	0.00	0.0	0.01	0.1	0.01	0.1	4.4	7.0	4.2	9.3	8.6	8.0	8.6	7.4
Kishoreganj	Broadcast	457	0.00	0.0	0.00	0.0	0.00	0.0	0.8	1.2*	1.6	3.6*	2.5	2.1*	2.5	1.9*
	UDP	532	0.00	0.0	0.00	0.0	0.00	0.0	4.6	7.3	4.6	7.4	9.2	7.3	9.2	6.2
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	0.7	0.4*	3.3	17.0*	4.0	2.0*	4.0	1.8*
	UDP	65	0.00	0.0	0.00	0.0	0.00	0.0	8.0	4.5	1.5	4.3	9.5	4.5	9.5	4.0
Mymensingh	Broadcast	364	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.3*	1.5	5.5*	1.7	1.7*	1.7	1.5*
	UDP	403	0.00	0.0	0.01	0.1	0.01	0.0	6.1	8.9	4.6	8.1	10.7	8.6	10.7	7.5
Netrokona	Broadcast	103	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0*	3.5	7.3*	3.6	2.8*	3.6	2.5*
	UDP	111	0.00	0.0	0.00	0.0	0.00	0.0	0.5	0.9	9.6	13.1	10.1	7.6	10.1	6.7
Noakhali	Broadcast	71	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0*	1.6	3.8*	1.6	2.0*	1.6	1.8*
	UDP	71	0.00	0.0	0.00	0.0	0.00	0.0	3.8	11.2	8.6	12.4	12.4	12.0	12.4	10.6
Sherpur	Broadcast	116	0.00	0.0	0.02	0.4	0.02	0.3	0.7	1.0*	2.0	5.4*	2.7	2.6*	2.7	2.5*
	UDP	157	0.00	0.0	0.00	0.0	0.00	0.0	4.9	7.9	4.7	9.5	9.6	8.6	9.6	7.8

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

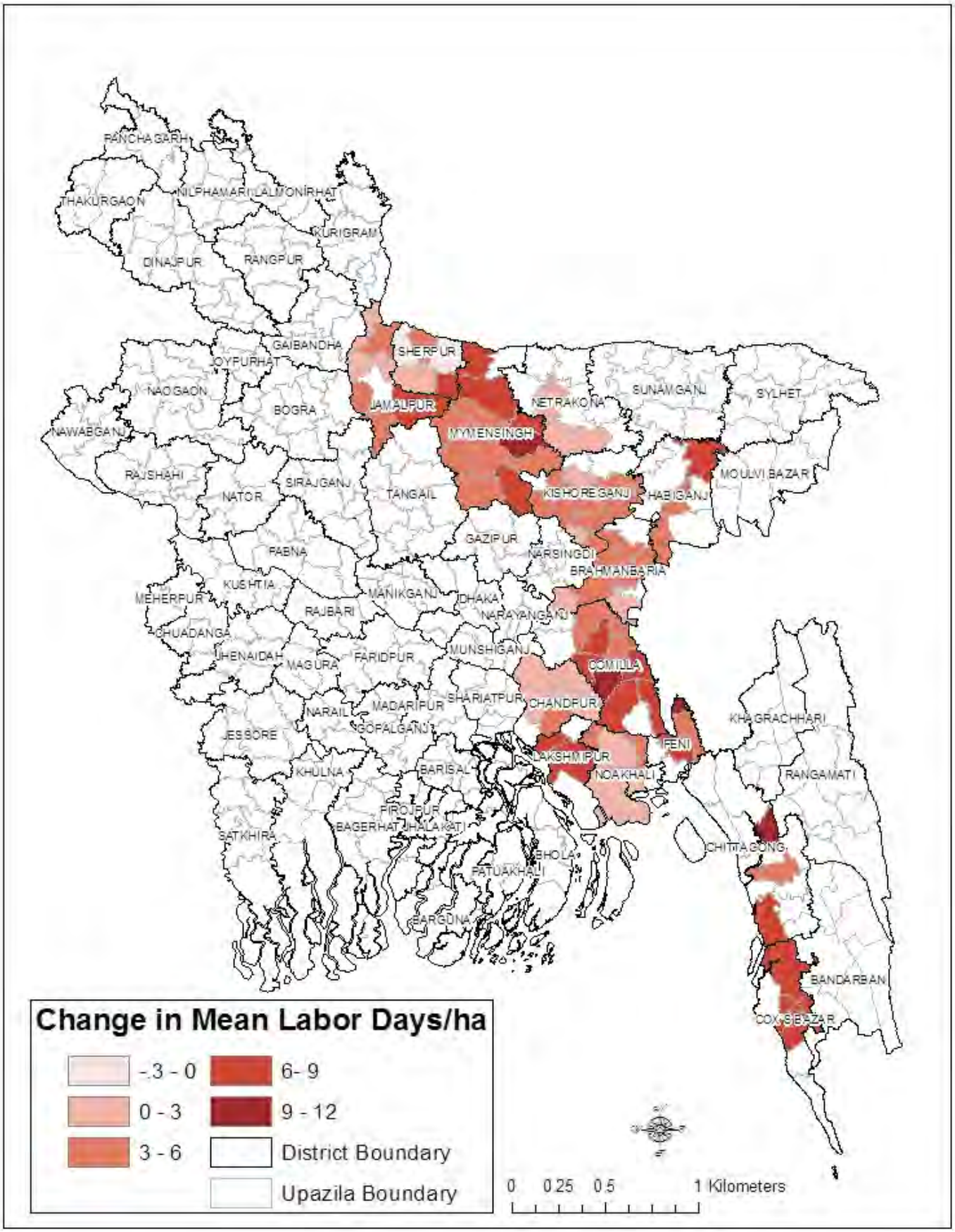

Figure 2. Changes in the Mean Labor Days Per Hectare of Hired Men for Urea Application for UDP Compared With Broadcast Urea

Table 9. Mean Labor Days Per Hectare for Other Fertilizer Application by District, Method of Urea Application and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	264	0.00	0.0	0.00	0.0	0.00	0.0	3.2	3.4	7.2	8.8*	10.4	5.9*	10.4	5.4*
	UDP	285	0.00	0.0	0.03	0.2	0.03	0.2	3.0	3.5	8.0	9.4	11.0	6.5	11.0	5.8
Chandpur	Broadcast	296	0.00	0.0	0.00	0.0	0.00	0.0	0.7	0.5*	2.4	3.2*	3.2	1.4*	3.2	1.3*
	UDP	192	0.00	0.0	0.00	0.0	0.00	0.0	1.3	0.6	5.4	4.0	6.7	1.9	6.7	1.7
Chittagong	Broadcast	32	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1	1.5	4.1*	1.6	1.3*	1.6	1.0*
	UDP	39	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1	2.2	3.9	2.3	1.7	2.3	1.5
Comilla	Broadcast	437	0.03	5.7	0.00	0.0	0.03	0.1	0.0	0.0	5.8	5.4*	5.9	2.7*	5.9	2.5*
	UDP	625	0.02	14.1	0.00	0.0	0.02	0.1	0.1	0.1	6.4	5.8	6.4	3.2	6.4	2.9
Cox's Bazaar	Broadcast	51	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.2	1.6	4.3	1.7	1.8	1.7	1.4
	UDP	58	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	1.8	3.0	1.8	1.5	1.8	1.2
Feni	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	2.5	5.3	2.8	10.1*	5.3	7.1*	5.3	6.4*
	UDP	105	0.00	0.0	0.00	0.0	0.00	0.0	2.7	5.5	3.9	8.9	6.6	7.1	6.6	6.3
Hobiganj	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.3	2.2	3.9*	2.3	2.0*	2.3	1.7*
	UDP	52	0.00	0.0	0.00	0.0	0.00	0.0	0.7	1.0	7.0	8.7	7.7	5.0	7.7	4.2
Jamalpur	Broadcast	338	0.00	0.0*	0.00	0.0	0.00	0.0*	0.2	0.3	1.5	4.2*	1.7	1.5*	1.7	1.5*
	UDP	381	0.01	5.2	0.00	0.0	0.01	0.1	0.3	0.5	2.5	5.5	2.8	2.5	2.8	2.4
Kishoreganj	Broadcast	444	0.00	0.0	0.00	0.0	0.00	0.0	0.8	1.1*	1.9	4.1*	2.7	2.3*	2.7	2.0*
	UDP	513	0.00	0.0	0.00	0.0	0.00	0.0	0.6	1.0	3.2	4.9	3.8	2.9	3.8	2.5
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	9.0	5.0	1.6	8.2*	10.5	5.3*	10.5	4.9*
	UDP	65	0.00	0.0	0.00	0.0	0.00	0.0	9.3	5.3	5.7	16.3	15.0	7.1	15.0	6.3
Mymensingh	Broadcast	363	0.00	0.0	0.00	0.0	0.00	0.0	1.0	1.4	1.6	5.9*	2.6	2.6*	2.6	2.3*
	UDP	387	0.00	0.0	0.00	0.0	0.00	0.0	1.6	2.3	4.0	6.8	5.7	4.4	5.7	3.8
Netrokona	Broadcast	41	0.00	0.0	0.00	0.0	0.00	0.0	0.4	0.2	2.0	1.7*	2.5	0.8*	2.5	0.7*
	UDP	36	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1	2.7	1.2	2.9	0.7	2.9	0.6
Noakhali	Broadcast	71	0.00	0.0	0.00	0.0	0.00	0.0	1.8	4.8*	3.3	7.6*	5.1	6.3	5.1	5.6
	UDP	70	0.00	0.0	0.00	0.0	0.00	0.0	1.0	3.0	4.2	6.0	5.3	5.0	5.3	4.4
Sherpur	Broadcast	116	0.00	0.0	0.00	0.0	0.00	0.0	1.4	2.1	1.9	5.1*	3.3	3.3	3.3	3.1*
	UDP	139	0.00	0.0	0.00	0.0	0.00	0.0	3.5	5.1	5.0	9.0	8.6	6.8	8.6	6.2

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

of men for this task in all other sample districts increased significantly. Overall, the total labor for the application of other fertilizers increased significantly after the adoption of UDP.

Weeding

As noted earlier and shown in Table 10, the labor requirement for weeding decreases with the adoption of UDP. There are two reasons for less weeding in UDP paddy fields. First, the USG is placed in the soil well below the weed roots and the weeds are more deprived of nutrients and do not flourish well. Second, paddy fertilized with USG forms a canopy of foliage sooner than broadcast paddy and thus shadows the soil so that weeds are more deprived of sunlight and their growth is slowed.

Weeding is the first task discussed in which the data show definitive labor input by hired women, namely in Chittagong and Cox's Bazaar. Although the labor of hired women decreased with the introduction, that decrease is not statistically significant. In Cox's Bazaar, the adoption of UDP did result in a significant decrease in the labor of hired women for weeding. This an exception to the observation. An example is rice cultivation in Bangladesh. Here, women rarely own land. They work as unpaid laborers on their men's fields or are not even allowed to enter the fields (Van Koppen, 2000). This exception to the division of labor and gender appears to be a consequence of specific subnational socio-economic circumstances in Chittagong and Cox's Bazaar.

Chittagong is the second largest city in Bangladesh and a commercial capital city. It is also the largest sea port in the country and where most of the large industries of Bangladesh are located. A major sector of the economy in Cox's Bazaar is tourism; the hospitality industry is a major employer in the area. Thus, labor is drawn from the rural areas and comprises mainly, but not exclusively, men. Although weeding is predominately a task of men, these reasons explain why women are more involved in weeding.

Following the introduction of UDP, the mean labor days per hectare of hired men decreased substantially with statistical significance in each sample district. Although farmers saved money because of the reduced weeding requirement and need for hired labor, the earnings of hired men and women in Chittagong for weeding were significantly reduced.

The mean labor days per hectare of household men also decreased with statistical significance in Brahmanbaria, Chandpur, Comilla and Jamalpur. This labor for weeding significantly increased in Feni, Kishoreganj, Mymensingh, Netrokona and Noakhali. The introduction of UDP had no statistically significant effect on the mean labor days per hectare of household men for weeding in the districts of Chittagong, Cox's Bazaar, Hobiganj, Laxmipur and Sherpur.

The total labor of all men for weeding either decreased significantly or was not significantly affected by the introduction of UDP. Statistically significant decreases in labor were found in Brahmanbaria, Chandpur, Comilla, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Noakhali and Sherpur. No significant changes in the labor of total men for weeding were found in Chittagong, Cox's Bazaar, Hobiganj, Laxmipur and Sherpur. In Table 10, the distribution of labor days for weeding by all men is reflected in the distribution for total labor. Importantly, in no case did the new urea application practice increase the total labor input of men for the task of weeding. As with land preparation, transplanting, urea application and application of other fertilizers, those who adopted UDP saved financial resources by a reduced need to hire labor for weeding. Fewer weeds also reduced the need for the labor of household men. Unlike the financial savings that were realized through the reduced need for hired labor for the previous tasks (which were anticipatory), the evidence of reduced weeds and required labor was observed after the rice plants were established.

The geographical distribution of labor changes of hired men for weeding, due to UDP adoption, is presented in Figure 3. Grouping neighbor upazilas indicates that the spatial variability resulting from the impact of UDP adoption on labor is not random but the result of local characteristics interacting with UDP adoption. Only two upazilas, Chatkhil in northwestern Noakhali district and Bashkhali in southwestern Chittagong (2.3 percent of surveyed area), showed no change or increase in the labor of hired men for weeding in the range of 0–13 days/ha. The remainder of surveyed upazilas showed decreases in the labor of hired men for weeding, with the greatest decreases of 20 days/ha or more in the central upazilas of Chandpur and central and northern Comilla.

Table 10. Mean Labor Days Per Hectare for Weeding by District, Method of Urea Application and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	264	0.05	1.9	0.02	0.1	0.06	0.4	21.4	22.9*	17.2	21.0*	38.6	22.0*	38.7	20.2*
	UDP	283	0.00	0.0	0.06	0.4	0.06	0.3	9.4	11.1	13.2	15.4	22.7	13.2	22.7	12.0
Chandpur	Broadcast	297	0.25	21.2	0.00	0.0	0.25	1.0	51.4	36.3	25.3	33.8*	76.7	35.4*	77.0	31.7*
	UDP	331	0.00	0.0	0.04	0.1	0.04	0.1	29.4	24.3	16.8	21.6	46.2	23.2	46.2	20.0
Chittagong	Broadcast	31	4.69	87.6	0.00	0.0	4.69	14.6	14.2	15.4*	6.6	17.9	20.8	16.1	25.5	15.8
	UDP	34	4.58	86.3	0.00	0.0	4.58	15.9	7.9	8.8	8.5	13.0	16.4	10.6	20.9	11.4
Comilla	Broadcast	438	0.00	0.0	0.00	0.0	0.00	0.0	27.9	25.4*	12.6	11.7*	40.5	18.6*	40.5	17.1*
	UDP	589	0.00	0.0	0.00	0.0	0.00	0.0	14.3	15.1	4.3	3.7	18.6	8.9	18.6	8.0
Cox's Bazaar	Broadcast	52	4.43	98.2*	0.00	0.0	4.43	17.7*	1.1	2.0*	3.4	9.6	4.5	4.9	9.0	7.6*
	UDP	48	2.43	100	0.00	0.0	2.43	6.1	0.0	0.0	3.3	4.7	3.3	2.3	5.8	3.1
Feni	Broadcast	104	0.00	0.0	0.00	0.0	0.00	0.0	7.9	16.5*	3.4	11.9*	11.3	14.8	11.3	13.3
	UDP	105	0.00	0.0	0.00	0.0	0.00	0.0	5.9	12.2	5.0	11.1	10.9	11.7	10.9	10.4
Hobiganj	Broadcast	50	0.33	20.0	0.00	0.0	0.33	2.2	4.3	7.0*	5.6	10.6	9.9	8.7	10.2	7.9
	UDP	50	0.00	0.0	0.00	0.0	0.00	0.0	2.7	3.4	6.3	7.6	9.0	5.6	9.0	4.8
Jamalpur	Broadcast	341	0.00	0.0	0.09	1.6	0.09	1.5	19.3	25.4*	9.3	26.5*	28.6	25.7*	28.7	24.5*
	UDP	385	0.00	0.0	0.00	0.0	0.00	0.0	6.4	10.2	9.2	20.4	15.6	14.4	15.6	13.4
Kishoreganj	Broadcast	458	0.00	0.0	0.00	0.0	0.00	0.0	25.2	35.7*	8.1	18.0*	33.3	28.8*	33.3	25.3*
	UDP	516	0.00	0.0	0.01	0.1	0.01	0.0	12.6	19.2	8.4	13.1	21.0	16.2	21.0	13.8
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	58.9	32.6*	1.3	6.6	60.2	30.1*	60.2	27.9*
	UDP	65	0.00	0.0	0.00	0.0	0.00	0.0	42.6	24.0	1.4	3.9	44.0	20.7	44.0	18.4
Mymensingh	Broadcast	377	0.00	0.0	0.00	0.0	0.00	0.0	12.5	17.6*	4.8	18.5*	17.3	17.8*	17.3	15.8*
	UDP	401	0.00	0.0	0.00	0.0	0.00	0.0	6.2	9.1	6.8	11.9	13.0	10.3	13.0	9.0
Netrokona	Broadcast	104	0.00	0.0	0.00	0.0	0.00	0.0	17.6	23.1*	4.3	8.9*	21.9	17.6	21.9	15.6
	UDP	112	0.00	0.0	0.00	0.0	0.00	0.0	13.4	22.4	6.9	9.5	20.3	15.4	20.3	13.6
Noakhali	Broadcast	71	0.00	0.0	0.10	1.1	0.10	1.0	8.9	23.8*	6.3	14.7*	15.3	19.0*	15.4	17.0*
	UDP	71	0.00	0.0	0.00	0.0	0.00	0.0	5.6	16.5	8.4	12.2	14.0	13.7	14.0	12.0
Sherpur	Broadcast	125	0.00	0.0	0.02	0.4	0.02	0.3	13.1	22.2*	8.9	25.8	22.1	23.5*	22.1	22.4*
	UDP	157	0.00	0.0	0.02	0.1	0.02	0.1	6.8	11.1	7.5	15.2	14.3	12.9	14.4	11.7

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

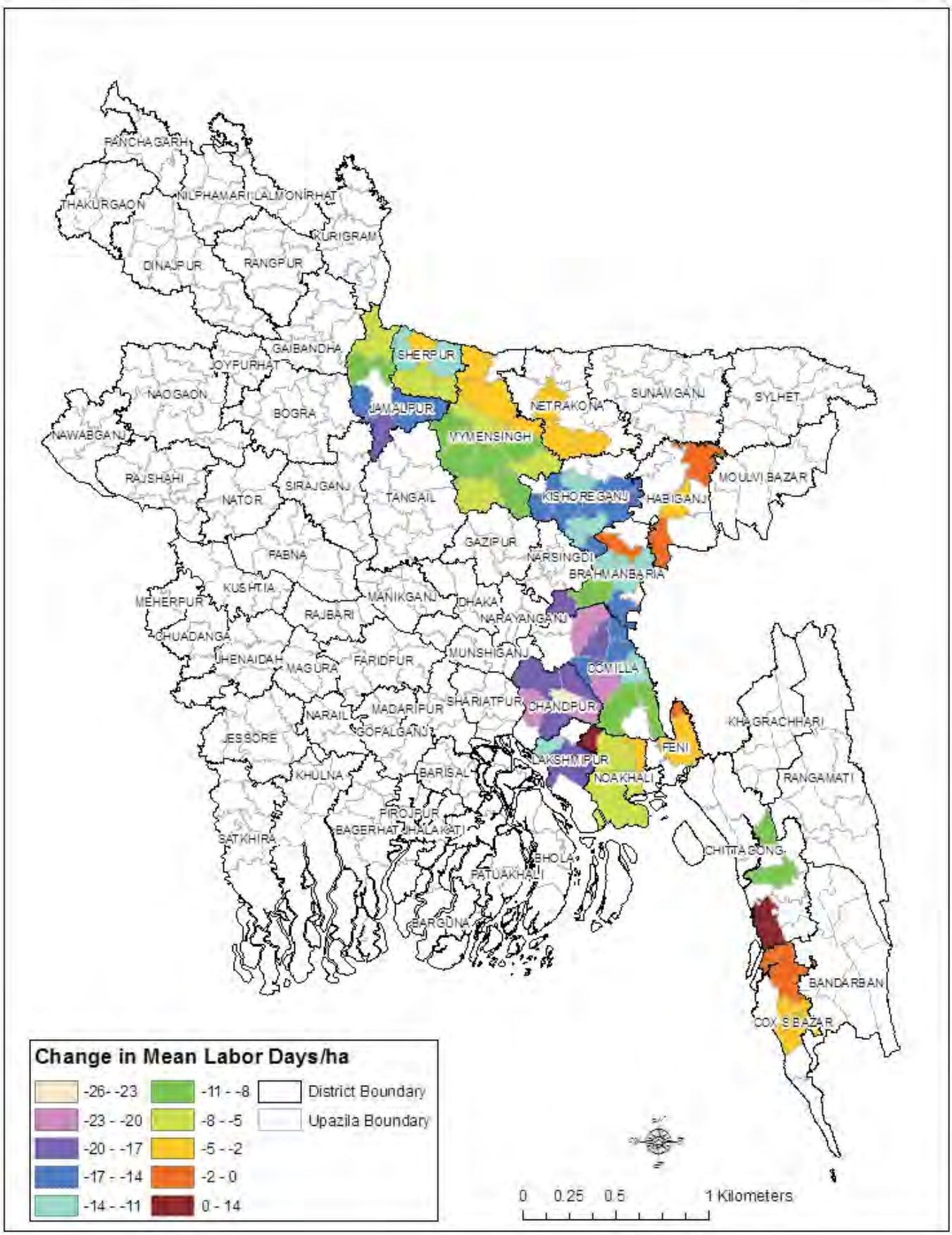

Figure 3. Changes in the Mean Labor Days Per Hectare of Hired Men for Weeding for UDP Compared With Broadcast Urea

Irrigation

The data in Table 11 show that hired women, household women and total women as laborers do not contribute significantly to the mean labor days per hectare for irrigation in the sample districts, except in Comilla. The introduction of UDP in Comilla resulted in a significant decrease in the labor contributed by women for irrigation.

The data show that regardless of the method of urea application, household men are mainly responsible for irrigation tasks. With the introduction of UDP, the mean labor days per hectare of household men for irrigation increased in Brahmanbaria, Chandpur, Comilla, Feni, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur, but there was no significant effect in Hobiganj and Jamalpur. The practice of UDP resulted in significant decreases in the labor of household men in Chittagong and Cox's Bazaar.

Labor for irrigation also decreased significantly for hired men in Comilla, Jamalpur and Laxmipur. Irrigation labor for hired men significantly increased only in Hobiganj. In the sample districts of Brahmanbaria, Chandpur, Cox's Bazaar, Feni, Kishoreganj, Mymensingh, Netrokona, Noakhali and Sherpur, the introduction of UDP did not significantly affect the labor of hired men for irrigation tasks.

With UDP, total mean labor days per hectare from all sources for irrigation tasks increased significantly in Brahmanbaria, Chandpur, Comilla, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona and Noakhali. In Jamalpur, total labor was not affected by the new method of urea application. In Chittagong and Cox's Bazaar, total labor for irrigation decreased significantly. The significant increases in the mean labor days per hectare for irrigation are explained by the water management recommendations for UDP. Of course, it is recommended that the paddy never be allowed to dry and that the water level remains rather constant, which requires more attention and care than with broadcast urea, according to those who adopted UDP. Thus, there were likely more frequent trips to the paddy field for inspection and water applications by household men rather than by household and hired women and hired men.

Application of Crop Protection Products

The data in Table 12 show that hired women, household women and total women as laborers do not contribute significantly to the mean labor days per hectare for application of crop protection products in the sample districts, regardless of the method of urea application. There are two exceptions to this pattern. In Chandpur and Mymensingh, the introduction of UDP significantly increased the labor of hired women. Despite the exceptions, application of crop protection products in the sample districts is a task that is clearly the domain of household men and, to a lesser extent, hired men.

For hired men, UDP resulted in a significant increase in the mean labor days per hectare for application of crop protection products in Feni, Hobiganj, Kishoreganj and Netrokona. In contrast, labor days decreased significantly for this task in Chandpur, Jamalpur and Laxmipur. The districts of Brahmanbaria, Chandpur, Comilla, Cox's Bazaar, Mymensingh, Noakhali and Sherpur showed no significant change in labor of hired men for this task. The adoption of UDP does not appear to significantly increase hired labor costs for the application of crop protection products.

For household men, UDP resulted in a statistically significant increase in the mean labor days per hectare for this task in Brahmanbaria, Chandpur, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur. In Chittagong, UDP did not affect the labor days of household men for application of crop protection products.

Table 12 also shows that total labor from all sources for application of crop protection products increased significantly in Brahmanbaria, Chandpur, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur due to UDP adoption. In the districts of Chittagong and Comilla, UDP had no significant effect on total labor for this task. These data suggest gender differences in the exposure to crop protection products. Although some research found that women and children are specifically at risk because they are frequently employed in mixing pesticides and refilling pesticide tanks (Rother, 2000; Mancini et al., 2005), men in all sample districts are more prone than women to such risks with notable exceptions in Chandpur and Mymensingh. In other districts, the exposure of women to such risks as a result of field work appears negligible.

Table 11. Mean Labor Days Per Hectare for Irrigation by District, Method of Urea Application and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	263	0.00	0.0	0.11	0.8	0.11	0.7	0.7	0.7	9.1	11.1*	9.8	5.5*	9.9	5.1*
	UDP	283	0.00	0.0	0.00	0.0	0.00	0.0	0.6	0.7	11.1	13.0	11.7	6.9	11.7	6.2
Chandpur	Broadcast	237	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.2	3.4	3.6*	3.7	1.3*	3.7	1.2*
	UDP	241	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.2	4.2	4.0	4.6	1.7	4.6	1.4
Chittagong	Broadcast	1	0.00	0.0	0.00	0.0	0.00	0.0	11.4	0.4	5.7	0.5	17.1	0.4	17.1	0.3
	UDP	0														
Comilla	Broadcast	431	0.00	0.0	0.04	0.2*	0.04	0.2*	0.1	0.1*	27.1	24.6*	27.2	12.3*	27.2	11.3*
	UDP	614	0.00	0.0	0.01	0.1	0.01	0.1	0.0	0.0	38.5	34.8	38.5	19.1	38.6	17.3
Cox's Bazaar	Broadcast	1	0.00	0.0*	0.00	0.0*	0.00	0.0*	0.0	0.0*	2.5	0.1*	2.5	0.1*	2.5	0.0*
	UDP	1	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	1.2	0.0	1.2	0.0	1.2	0.0
Feni	Broadcast	104	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.4	1.5	5.4*	1.7	2.2*	1.7	2.0*
	UDP	102	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.1	2.1	4.7	2.2	2.3	2.2	2.0
Hobiganj	Broadcast	50	0.08	5.0	0.00	0.0	0.08	0.6	0.8	1.3*	6.1	11.7	6.9	6.1*	7.0	5.4*
	UDP	53	0.00	0.0	0.00	0.0	0.00	0.0	2.7	3.6	8.2	10.4	10.8	7.1	10.8	6.1
Jamalpur	Broadcast	11	0.00	0.0	0.00	0.0	0.00	0.0	1.5	0.1*	3.8	0.3	5.3	0.2	5.3	0.1
	UDP	32	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.0	5.0	0.9	5.3	0.4	5.3	0.4
Kishoreganj	Broadcast	455	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.1	10.6	23.2*	10.6	9.1*	10.6	8.0*
	UDP	520	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	17.5	27.4	17.5	13.6	17.5	11.6
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	1.0	0.5*	6.0	30.9*	7.0	3.5*	7.0	3.2*
	UDP	64	0.00	0.0	0.00	0.0	0.00	0.0	0.5	0.3	11.0	30.9	11.5	5.3	11.5	4.7
Mymensingh	Broadcast	340	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.4	2.3	8.0*	2.6	2.4*	2.6	2.2*
	UDP	351	0.00	0.0	0.01	0.1	0.01	0.0	0.4	0.5	4.7	7.2	5.1	3.5	5.1	3.1
Netrokona	Broadcast	104	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.3	10.7	22.1*	10.9	8.8*	10.9	7.8*
	UDP	110	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.3	15.0	20.3	15.2	11.3	15.2	10.0
Noakhali	Broadcast	71	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	1.6	3.8*	1.6	2.0*	1.6	1.8*
	UDP	70	0.04	2.7	0.04	0.3	0.08	0.5	0.0	0.0	2.8	4.0	2.8	2.7	2.9	2.5
Sherpur	Broadcast	50	0.00	0.0	0.00	0.0	0.00	0.0	0.5	0.3	3.5	4.1*	4.0	1.7*	4.0	1.6*
	UDP	65	0.00	0.0	0.04	0.1	0.04	0.1	0.7	0.5	4.8	4.0	5.5	2.0	5.5	1.9

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

Table 12. Mean Labor Days Per Hectare for Application of Crop Protection Products by District, Method of Urea and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	135	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.0	0.5	0.3*	0.6	0.2*	0.6	0.2*
	UDP	47	0.00	0.0	0.00	0.0	0.00	0.0	0.7	0.1	1.5	0.3	2.2	0.2	2.2	0.2
Chandpur	Broadcast	271	0.00	0.0*	0.00	0.0	0.00	0.0*	0.5	0.3*	3.5	4.3*	3.9	1.7*	3.9	1.5*
	UDP	295	0.01	0.8	0.00	0.0	0.01	0.0	0.2	0.2	3.9	4.5	4.2	1.9	4.2	1.6
Chittagong	Broadcast	29	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1	1.6	4.1	1.7	1.2	1.7	1.0
	UDP	33	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1	2.0	2.9	2.1	1.3	2.1	1.1
Comilla	Broadcast	179	0.00	0.0	0.00	0.0	0.00	0.0	2.0	0.8	0.8	0.3	2.8	0.5	2.8	0.5
	UDP	301	0.00	0.0	0.00	0.0	0.00	0.0	2.0	1.1	0.8	0.4	2.9	0.7	2.9	0.6
Cox's Bazaar	Broadcast	51	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1	1.5	4.2*	1.6	1.7*	1.6	1.3*
	UDP	56	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	1.8	3.0	1.9	1.5	1.9	1.2
Feni	Broadcast	61	0.00	0.0	0.00	0.0	0.00	0.0	0.1	0.1*	1.1	2.3*	1.2	0.9*	1.2	0.8*
	UDP	56	0.00	0.0	0.00	0.0	0.00	0.0	0.4	0.4	1.8	2.1	2.2	1.2	2.2	1.1
Hobiganj	Broadcast	35	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.4	1.4	1.9*	1.8	1.1*	1.8	1.0*
	UDP	9	0.00	0.0	0.00	0.0	0.00	0.0	2.6	0.6	4.4	1.0	7.1	0.8	7.1	0.7
Jamalpur	Broadcast	139	0.00	0.0	0.00	0.0	0.00	0.0	0.4	0.2*	1.7	2.0*	2.1	0.8*	2.1	0.7*
	UDP	157	0.00	0.0	0.00	0.0	0.00	0.0	0.2	0.1	2.4	2.2	2.6	1.0	2.6	0.9
Kishoreganj	Broadcast	287	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0*	0.5	0.7*	0.5	0.3*	0.5	0.2*
	UDP	56	0.00	0.0	0.00	0.0	0.00	0.0	0.8	0.1	3.0	0.5	3.9	0.3	3.9	0.3
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	1.8	1.0*	3.2	16.6*	5.1	2.5*	5.1	2.3*
	UDP	63	0.00	0.0	0.08	0.6	0.08	0.3	1.3	0.7	6.9	19.2	8.2	3.8	8.3	3.4
Mymensingh	Broadcast	201	0.00	0.0	0.00	0.0*	0.00	0.0*	0.1	0.0	0.6	1.2*	0.7	0.4*	0.7	0.3*
	UDP	142	0.00	0.0	0.01	0.0	0.01	0.0	0.1	0.1	2.9	1.8	3.0	0.9	3.0	0.7
Netrokona	Broadcast	11	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0*	2.1	0.5*	2.1	0.2*	2.1	0.2*
	UDP	10	0.00	0.0	0.00	0.0	0.00	0.0	0.9	0.1	5.1	0.6	6.0	0.4	6.0	0.4
Noakhali	Broadcast	58	0.00	0.0	0.00	0.0	0.00	0.0	0.3	0.7	1.5	2.8*	1.8	1.8*	1.8	1.6*
	UDP	55	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.1	3.0	3.4	3.1	2.3	3.1	2.0
Sherpur	Broadcast	39	0.00	0.0	0.00	0.0	0.00	0.0	0.9	0.5	1.1	1.0*	2.0	0.7*	2.0	0.6
	UDP	40	0.00	0.0	0.00	0.0	0.00	0.0	0.7	0.3	3.5	1.8	4.1	1.0	4.1	0.9

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

Harvesting and Carrying

The data in Table 13 clearly show that hired and household women do not make significant labor contributions to the tasks of harvesting and carrying, except in two districts. In Mymensingh, the hired labor of women and total labor of women increased significantly with the introduction of UDP. In Sherpur, the hired labor of women also increased significantly, but there was no significant change in the total labor of women for this task.

Table 13 also shows that the adoption of UDP resulted in no significant change in the mean labor days per hectare of hired men for harvesting and carrying in Brahmanbaria, Chandpur, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Laxmipur and Mymensingh. In contrast, labor for hired men increased significantly in Kishoreganj, Noakhali and Sherpur. Statistically significant decreases in the labor of hired men were observed in Chittagong, Comilla and Netrokona.

As a result of the substantial increases in paddy yield attributable to UDP, the mean labor days per hectare of household men increased significantly in Chandpur, Chittagong, Cox's Bazaar, Feni, Jamalpur, Kishoreganj, Mymensingh, Netrokona, Noakhali and Sherpur. When compared with the practice of broadcast urea, UDP resulted in no significant change in the labor days of hired men for harvesting and carrying in Brahmanbaria, Comilla, Hobiganj and Laxmipur. Notably, UDP did not decrease the mean labor days per hectare of household men for harvesting and carrying in any of the sample districts.

The total labor of hired and household men for harvesting and carrying increased with statistical significance in Chandpur, Chittagong, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Mymensingh, Noakhali and Sherpur. Significant decreases in the total labor of men for this task were observed in Comilla and Netrokona, but UDP resulted in no significant change in Laxmipur.

For total labor from all sources for harvesting and carrying, the data show statistically significant increases in Chandpur, Chittagong, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Mymensingh, Noakhali and Sherpur. Compared with broadcast urea, the total labor from all sources for harvesting and carrying decreased significantly in Comilla. In Brahmanbaria, Laxmipur and Netrokona, the practice of UDP resulted in no significant change in total labor for harvesting and carrying.

Post-Harvest Tasks

As shown in Table 14, the UDP practice significantly increased the mean labor days per hectare of hired women for post-harvest work in Kishoreganj; however, compared with broadcast urea, that labor significantly decreased in Comilla, Feni and Mymensingh. The UDP practice resulted in no significant changes in the labor of hired women for harvesting and carrying in Brahmanbaria, Chandpur, Chittagong, Cox's Bazaar, Hobiganj, Jamalpur, Laxmipur, Netrokona Noakhali and Sherpur. The data also show that the mean labor days per hectare of household women for post-harvest tasks significantly and dramatically increase with adoption of UDP in all sample districts.

Figure 4 shows the geographical distribution of household women labor in post-harvest activities due to UDP. The Sharasti upazila in southeastern Chandpur shows a 57-day/ha increase in household women labor, the largest in the sampled area; Chandpur also had several upazilas with increases in the same type of labor ranging from 21 days/ha to 50 days/ha. About 73 percent of surveyed area showed increases in the household labor of women ranging between two days/ha and 20 days/ha. This includes most of the upazilas in Brahmanbaria, Comilla, Feni, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Noakhali and Sherpur districts. The remainder of the surveyed area (about 26.0 percent) showed increases in the post-harvest labor of household women ranging from 21 days/ha to 50 days/ha.

There is a good degree of correspondence between areas of high yield increases in Figure 1 and areas of high increases of household women labor in post-harvest activities in Figure 4. This relationship is shown in Figure 5. A model derived from survey results in the 80 upazilas indicates that a paddy yield increase of 1 mt/ha results in an increase in the labor of household women by approximately 11 days/ha when urea application changes from broadcasting to UDP. Finally, Figure 5 shows that 69.0 percent of the variation in the household labor of women for post-harvest tasks is explained by the increased yield attributable to UDP.

Table 13. Mean Labor Days Per Hectare for Harvesting and Carrying by District, Method of Urea and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Household Women		Total Women		Hired Men		Household Men		Total Men		Total Labor	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	266	0.21	8.6	0.22	1.6	0.43	2.7	30.4	32.8	13.4	16.5	43.9	25.2	44.3	23.3
	UDP	286	0.00	0.0	0.17	1.1	0.17	0.9	31.4	37.2	13.5	15.8	44.9	26.5	45.1	24.0
Chandpur	Broadcast	296	0.13	10.6	0.06	0.2	0.18	0.7	31.4	22.0	4.4	5.8*	35.7	16.4*	35.9	14.8*
	UDP	334	0.00	0.0	0.00	0.0	0.00	0.0	32.3	26.9	5.5	7.2	37.9	19.2	37.9	16.6
Chittagong	Broadcast	32	0.00	0.0	0.00	0.0	0.00	0.0	16.7	18.6*	6.9	19.2*	23.5	18.7*	23.5	15.0*
	UDP	40	0.00	0.0	0.00	0.0	0.00	0.0	14.0	18.4	11.2	20.2	25.3	19.2	25.3	16.2
Comilla	Broadcast	440	0.00	0.0	0.02	0.1	0.02	0.1	25.3	23.1*	15.8	14.7	41.1	19.0*	41.1	17.5*
	UDP	627	0.00	0.0	0.12	0.6	0.12	0.6	21.5	24.2	15.5	14.3	37.0	18.7	37.1	17.0
Cox's Bazaar	Broadcast	51	0.00	0.0	0.08	0.4	0.08	0.3	12.0	20.5	6.9	19.0*	18.9	20.0*	19.0	15.8*
	UDP	59	0.00	0.0	0.00	0.0	0.00	0.0	11.7	19.1	11.7	20.2	23.4	19.6	23.4	15.4
Feni	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	18.3	38.8	4.4	15.8*	22.8	30.2*	22.8	27.2*
	UDP	105	0.00	0.0	0.00	0.0	0.00	0.0	17.0	35.0	6.4	14.4	23.4	25.1	23.4	22.4
Hobiganj	Broadcast	50	0.41	25.0	0.00	0.0	0.41	2.8	20.7	33.8	7.3	13.8	28.0	24.6*	28.4	22.1*
	UDP	54	0.00	0.0	0.00	0.0	0.00	0.0	25.7	35.4	7.5	9.7	33.2	22.2	33.2	18.9
Jamalpur	Broadcast	340	0.02	8.2	0.03	0.6	0.05	0.9	21.9	28.7	7.2	20.4*	29.0	26.1*	29.1	24.8*
	UDP	386	0.01	6.4	0.04	0.5	0.05	0.7	22.2	35.3	8.9	19.8	31.1	28.8	31.2	26.9
Kishoreganj	Broadcast	457	0.00	0.0	0.03	0.2	0.03	0.2	20.2	28.5*	5.4	12.0*	25.6	22.0*	25.6	19.4*
	UDP	528	0.00	0.0	0.02	0.1	0.02	0.1	21.0	32.8	7.3	11.6	28.2	22.3	28.3	19.0
Laxmipur	Broadcast	48	0.00	0.0	0.00	0.0	0.00	0.0	58.6	32.5	0.6	3.2	59.2	29.6	59.2	27.4
	UDP	65	0.00	0.0	0.00	0.0	0.00	0.0	56.9	32.1	1.2	3.5	58.1	27.4	58.1	24.3
Mymensingh	Broadcast	379	0.05	1.1	0.00	0.0*	0.05	0.4*	22.9	32.4	4.2	16.1*	27.1	28.0*	27.1	24.8*
	UDP	402	0.00	0.0	0.23	1.5	0.23	1.2	22.3	32.8	11.1	19.4	33.4	26.7	33.6	23.4
Netrokona	Broadcast	106	0.00	0.0	0.00	0.0	0.00	0.0	23.4	31.2*	4.6	9.7*	28.0	22.9*	28.0	20.3
	UDP	111	0.00	0.0	0.12	0.7	0.12	0.7	20.1	33.2	5.5	7.6	25.6	19.2	25.7	17.1
Noakhali	Broadcast	70	0.18	22.6	0.00	0.0	0.18	1.7	12.1	31.8*	8.7	20.0*	20.8	25.5*	21.0	22.8*
	UDP	71	0.00	0.0	0.00	0.0	0.00	0.0	13.7	40.7	13.6	19.7	27.3	26.6	27.3	23.4
Sherpur	Broadcast	125	0.10	42.8	0.32	6.6*	0.42	8.3	17.5	29.6*	6.7	19.2*	24.2	25.8*	24.6	24.9*
	UDP	159	0.00	0.0	1.49	12.8	1.49	12.7	19.5	32.1	10.1	20.6	29.5	27.0	31.0	25.6

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

Table 14. Mean Labor Days Per Hectare for Post-Harvest Tasks by District, Method of Urea and Gender

District	Type of Urea Application	N	Mean Labor Days Per Hectare													
			Hired Women		Hired Women		Hired Women		Hired Women		Hired Women		Hired Women		Hired Women	
			(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)	(days)	(%)
Brahmanbaria	Broadcast	266	2.15	87.2	13.3	97.5*	15.4	95.9*	4.7	5.0	8.3	10.3*	13.0	7.5	28.4	14.9*
	UDP	286	2.69	98.9	15.6	97.8	18.3	98.0	4.0	4.8	9.2	10.8	13.2	7.8	31.5	16.7
Chandpur	Broadcast	297	0.65	54.4	24.5	99.6*	25.2	97.5*	19.2	13.5*	16.9	22.6*	36.1	16.7	61.3	25.3*
	UDP	335	1.53	99.2	29.9	99.8	31.5	99.8	18.8	15.7	19.3	25.1	38.0	19.4	69.5	30.5
Chittagong	Broadcast	32	0.64	12.4	16.3	62.8*	16.9	54.4*	13.5	15.1*	5.6	15.7	19.2	15.2	36.1	23.0
	UDP	39	0.63	13.7	20.4	100	21.1	84.1	10.7	13.7	7.1	12.5	17.8	13.2	38.9	24.3
Comilla	Broadcast	439	0.40	90.7*	18.3	99.7*	18.7	99.5*	13.6	12.4*	16.0	14.9*	29.7	13.6*	48.3	20.5*
	UDP	625	0.10	63.8	21.0	99.2	21.1	99.0	12.2	13.7	18.5	17.0	30.7	15.5	51.8	23.6
Cox's Bazaar	Broadcast	52	0.08	1.8	20.4	99.2*	20.5	81.7*	11.6	20.3*	5.8	16.4*	17.5	18.8	37.9	32.2*
	UDP	59	0.00	0.0	30.6	100	30.6	93.9	9.1	14.8	8.3	14.3	17.3	14.6	48.0	31.6
Feni	Broadcast	106	0.50	100*	7.9	100*	8.4	100*	0.7	1.5	6.3	22.6*	7.0	9.3*	15.4	18.4*
	UDP	106	0.34	100	11.0	100	11.4	100	0.8	1.6	9.6	21.9	10.4	11.3	21.8	21.0
Hobiganj	Broadcast	50	0.16	10.0	13.1	100*	13.3	90.0*	7.7	12.6	9.8	18.5*	17.5	15.3*	30.8	23.9*
	UDP	54	0.00	0.0	25.5	100	25.5	100	8.3	11.5	16.4	21.2	24.8	16.5	50.3	28.7
Jamalpur	Broadcast	343	0.22	83.6	5.4	97.6*	5.6	97.0*	5.3	7.0*	3.2	9.2*	8.5	7.7*	14.2	12.2*
	UDP	389	0.16	88.5	7.7	99.4	7.9	99.1	5.3	8.4	4.7	10.6	10.0	9.3	17.9	15.5
Kishoreganj	Broadcast	458	3.11	99.7*	12.5	99.7*	15.6	99.7*	1.6	2.3*	6.8	14.9*	8.4	7.2*	24.0	18.2*
	UDP	532	4.62	100	17.3	99.8	21.9	99.8	2.4	3.8	9.4	15.1	11.9	9.4	33.7	22.8
Laxmipur	Broadcast	48	7.80	100	8.0	100*	15.8	100*	5.0	2.7*	2.3	12.1	7.3	3.7	23.1	10.7*
	UDP	65	12.8	100	13.5	99.4	26.3	99.7	3.5	2.0	2.7	7.8	6.2	2.9	32.5	13.6
Mymensingh	Broadcast	378	4.55	97.5*	8.0	100*	12.5	99.1*	7.1	10.1	4.7	18.2*	11.8	12.2*	24.4	22.3*
	UDP	403	3.69	100	14.7	98.3	18.3	98.6	8.0	11.7	9.9	17.4	17.9	14.3	36.2	25.3
Netrokona	Broadcast	105	0.00	0	15.8	100	15.8	100	3.3	4.3	15.8	32.9*	19.0	15.4*	34.8	25.0*
	UDP	112	0.00	0	16.7	99.3	16.7	99.3	2.5	4.1	19.6	27.0	22.0	16.6	38.7	25.9
Noakhali	Broadcast	70	0.60	77.4	9.3	97.8*	10.0	96.2*	0.4	1.1	7.3	16.7*	7.7	9.4	17.7	19.2*
	UDP	71	1.25	97.3	13.0	99.7	14.3	99.5	0.4	1.2	10.7	15.5	11.1	10.8	25.3	21.7
Sherpur	Broadcast	125	0.10	40.6	4.5	92.7*	4.6	90.3*	5.4	9.2*	3.9	11.3*	9.3	10.0*	13.9	14.1*
	UDP	156	0.12	100	10.3	86.9	10.4	87.0	7.2	11.6	7.7	15.6	14.9	13.4	25.3	20.5

% indicates the percentage of labor days with respect to total labor days from all tasks in the growing season.
*Significant difference between urea application types at the 0.05 level.

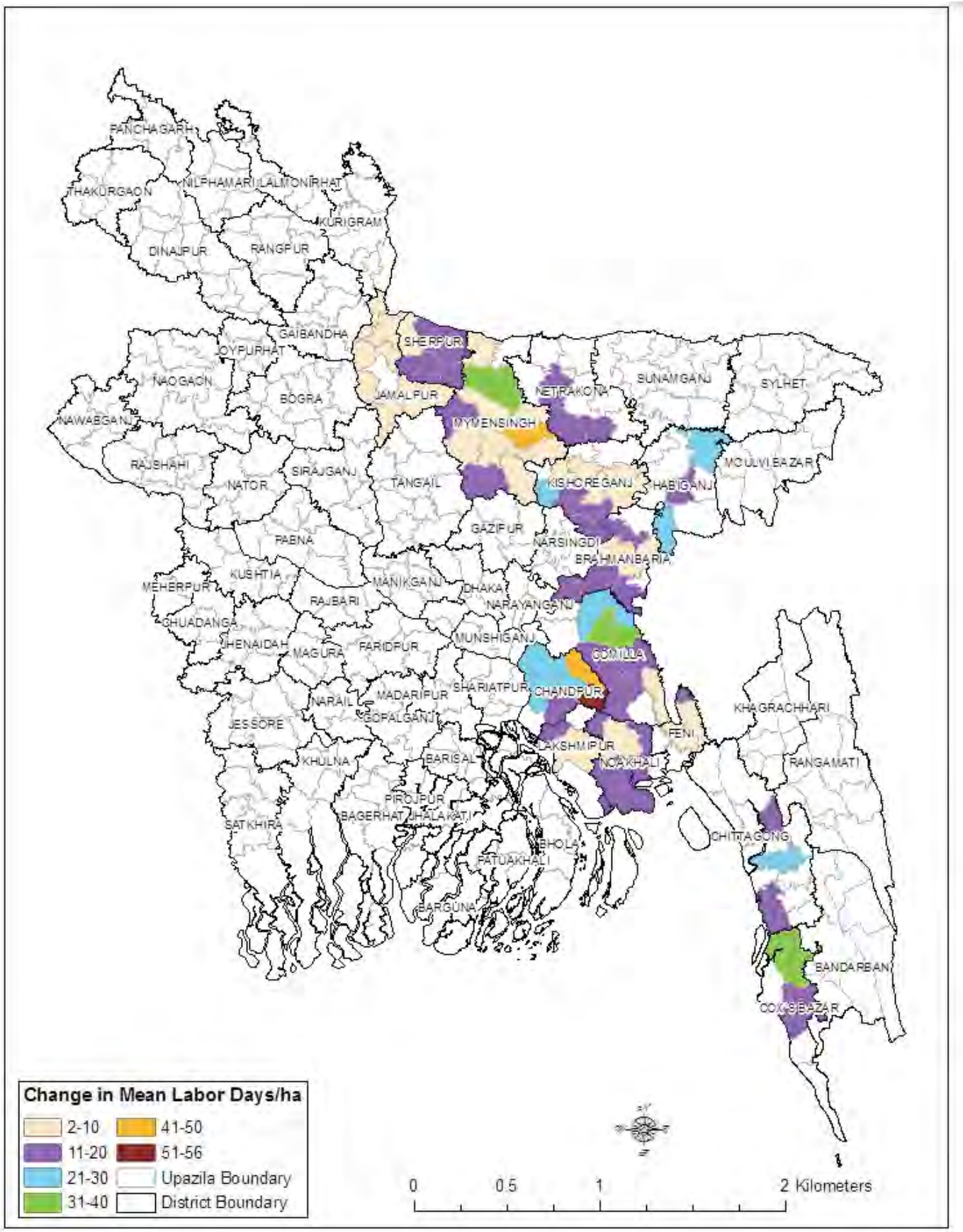

Figure 4. Changes in the Mean Labor Days Per Hectare of Household Women for Post-Harvest Tasks for UDP Compared With Broadcast Urea

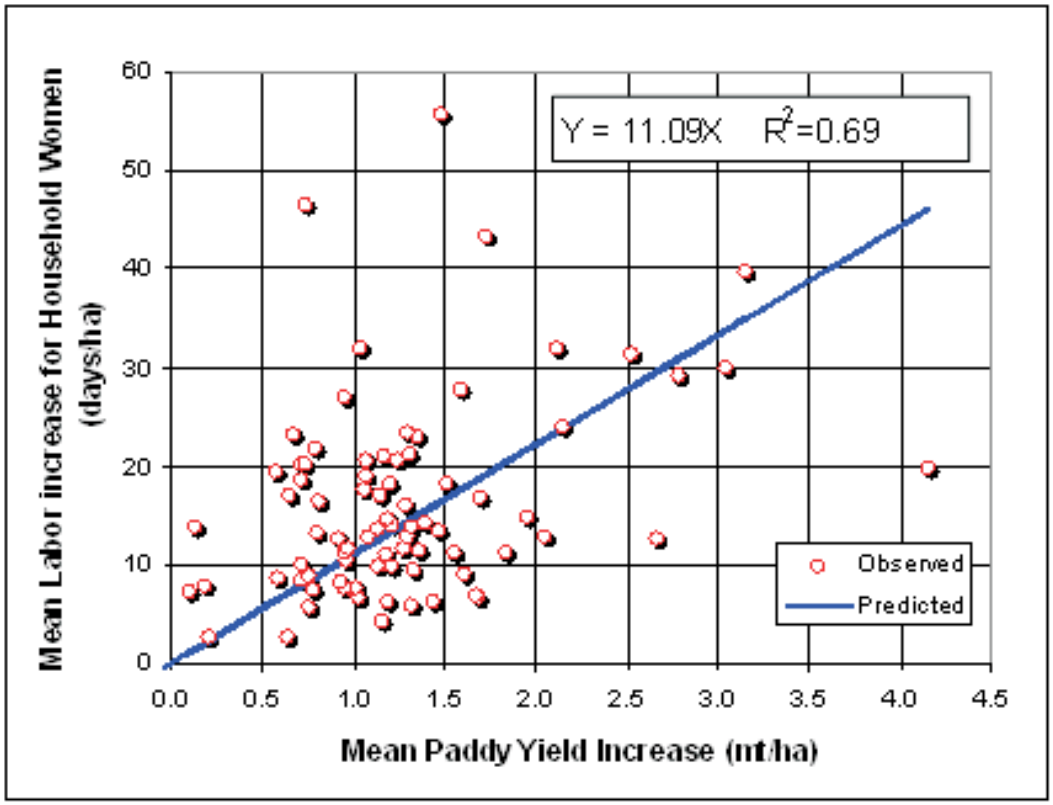

Figure 5. Relationship Between Mean Incremental UDP Paddy Yield and Mean Labor Days of Household Women for Post-Harvest Tasks

"In reality among poor households, such clearly demarcated gender divisions of labour do not apply. The traditional gender relations with women's involvement in post-harvest work and men's in fieldwork have not remained static over time. Presently, due to extreme poverty and a food crisis, social norms and traditions are changing and women are appearing in the field as well" (Shirin, 1995).

We also found no evidence to support the conclusion that there is a tendency toward the growing involvement of women in field-based activities because of male migration and male involvement in off-farm activities. In the past, women's increased responsibilities were not considered acceptable, but because of other changing socio-economic factors obliging women to take over men's responsibilities, this is becoming more acceptable. Field activities are now defined in such a way that they can be seen as part of the overall household duties (Jordans and Zwarteveen, 1997).

Compared with broadcast urea, UDP also dramatically increases the mean labor days per hectare of total women labor for post-harvest tasks in Brahmanbaria, Chandpur, Chittagong, Comilla, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Noakhali and Sherpur (93.0 percent of the sample districts). With the adoption of UDP, the total labor of women for post-harvest tasks also increased in Netrokona but the change was not statistically significant. Clearly, the practice of UDP appreciably and extensively increases the workload of household women and total women laborers involved in paddy production in the sample districts.

Compared with broadcast urea, the mean labor days per hectare of hired men for post-harvest tasks increased significantly with the adoption of UDP in Kishoreganj and Sherpur. Labor for hired men decreased significantly in Chandpur, Chittagong, Comilla, Cox's Bazaar, Jamalpur and Laxmipur. In contrast, the

labor of women in these districts increased significantly. UDP did not result in significant changes for the labor of hired men in Feni, Hobiganj, Mymensingh, Netrokona and Noakhali.

For household men, the mean labor days per hectare for post-harvest tasks also increased significantly in Brahmanbaria, Chandpur, Comilla, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Mymensingh, Netrokona, Noakhali and Sherpur (86.0 percent of the sample districts). Labor also increased in Chittagong and Laxmipur but without statistical significance.

The total labor of men for post-harvest tasks increased significantly in Comilla, Feni, Hobiganj, Jamalpur, Kishoreganj, Mymensingh, Netrokona, Noakhali and Sherpur. UDP resulted in no significant increase in the total labor of men in Brahmanbaria, Chandpur, Chittagong, Cox's Bazaar and Laxmipur. UDP did not result in a decrease in the total mean labor days per hectare for total men in any district.

For total labor from all sources, the mean labor days per hectare for post-harvest tasks also increased significantly in Brahmanbaria, Chandpur, Comilla, Cox's Bazaar, Feni, Hobiganj, Jamalpur, Kishoreganj, Laxmipur, Mymensingh, Netrokona, Noakhali and Sherpur (93.0 percent of the sample districts). That labor also increased in Chittagong but without statistical significance.

Total Labor from the Nine Paddy Production Tasks

The accumulated labor from the nine tasks required for paddy production was about 10 days/ha higher in the UDP fields than in the urea broadcast fields for the entire geographical area surveyed (Table 3). But such a significantly higher labor demand for paddy production with UDP did not occur in all districts; some districts showed no significant difference between the total labor demanded by the two methods of urea application. These districts include Brahmanbaria, Chittagong, Jamalpur and Laxmipur (Table 4).

Table 3 indicates that the only fraction of total labor that significantly decreased due to UDP adoption was hired men. The reduction was by about 10 days/ha. The main reason for the decrease in the total labor of hired men was due to a significant reduction in the number of men hired for weeding when UDP is used (Table 5); that reduction was also about 10 days/ha.

Wage Equity

To analyze and compare wage equity, we took a subsample of tasks in which men and women worked for wages. The data presented in Table 15 suggest that adoption of UDP for paddy production contributes to wage equity between men and women in Bangladesh. A comparison of the wages of hired women and men is shown in Table 16. The method of urea application has a significant effect on the distribution of percentage of women across the three categories of wages. The percentage of women who receive a wage less than men is 3.62 percent and significantly lower in households where UDP was adopted. The percentage of women receiving wages equal to men is 6.48 percent and significantly higher in households where UDP was adopted. The substantial increase in paddy yields that result from UDP creates a significantly higher demand of women to work in post-harvest

Table 15. A Comparison of Wage Equity by Gender and Type of Urea Application

Wages of Women	N		Percentage		
	Broadcast	UDP	Broadcast	UDP	Difference
Less than men	224	182	49.23	45.61	-3.62*
Equal to men	210	210	46.15	52.63	6.48*
Greater than men	21	7	4.62	1.76	2.87
Total	455	399	100.0	100.0	

*Significant difference at the 0.05 level.

Table 16. Mean Daily Wages of Men and Women by Urea Application Method

Wages of Women	N		Mean Wage			
			Broadcast		UDP	
	Broadcast	UDP	Men	Women	Men	Women
			(US $/day)			
Less than men	224	182	2.59	1.77	2.64	1.75
Equal to men	210	210	2.62	2.62	2.64	2.64
Greater than men	21	7	1.66	3.34	2.90	4.03

activities. Improvement in wage equity is primarily a consequence of the substantial increase in paddy yields that result from UDP adoption. The significantly higher yields make the number of household women insufficient to cover the labor needs post harvest. The increased demand growth for the labor of women results in higher wage compensation.

Conclusions

Comparing means for the entire area studied, the total labor required for paddy production was 10 days/ha higher with UDP than with broadcast urea. However, the total labor means were not significantly different in the Brahmanbaria, Chittagong, Jamalpur and Laxmipur districts.

- Significant reductions in the labor of hired men for weeding when UDP is used resulted in significant reductions in total men hired for the accumulation of all tasks needed for paddy production in the surveyed geographical area. The average reduction in the total labor of hired men was about 10 days/ha.
- From the nine tasks required for paddy production in Bangladesh, only post-harvest activities are performed mainly by women in the entire area of study. Post-harvest activities are conducted mainly by household women; however, four districts (Brahmanbaria, Kishoreganj, Laxmipur and Mymensingh) show that hired women worked in post-harvest tasks.
- In Chittagong and Cox's Bazaar, the pattern of women working primarily in post-harvest activities is broken by the important number of women hired to do weeding work. Demand for women to work in weeding in these districts seems to be the result of non-agricultural economic activities that attract male labor.
- All of the 14 districts studied showed significant paddy yield increase as a result of adopting UDP technology. There were yield gains in 79 of the upazilas surveyed, ranging from 100 kg/ha to 3,000 kg/ha. A full 77.0 percent of the upazilas showed paddy yield increases between 1 mt/ha and 1.7 mt/ha.
- Increases in the labor of household women in post-harvest activities are primarily a consequence of paddy yield increases when UDP is adopted. For the entire area studied, an average of 1 mt increase in paddy yield due to UDP results in an increase of 11 days/ha worked by household women in post-harvest activities.
- The grouping of geographically contiguous upazilas that show a similar reaction to UDP adoption in paddy yield and post-harvest labor of household women indicates the similarity of those upazilas with respect to soil, weather, crop management and the interaction of these factors with UDP nitrogen management. Similarities in socio-economic characteristics of the upazila groups also contribute to their similarity in terms of women's labor.
- The grouping of neighboring upazilas due to similarities in the labor of hired men for urea application and weeding is explained by similarities in the upazilas' socio-economic factors.
- Transplanting, weeding and harvesting and carrying are performed mainly by hired men. The explanation may be because these three tasks, together with post-harvest activities, are the most labor

demanding (Table 5). Evidently, household men are insufficient for these three tasks. Another characteristic of this group of tasks that may contribute to the need of hiring men is that they need to be performed in short periods of time at critical stages of the crop cycle to avoid economic losses.

- Urea application, other fertilizer application, irrigation and application of crop protection products are mainly conducted by household men. The need to hire labor for these tasks is lower, because they are less labor demanding and their timing is usually less critical than transplanting, weeding and harvesting.
- Land preparation is a task performed by a balance of hired and household men. This task is not among the most labor-demanding activities, but the hiring that balances the number of days worked by household men may be the result of renting animals and machinery together with their handlers or operators.
- UDP adoption had an important effect on the wage equity of rice production workers in Bangladesh. For the entire study area, the use of UDP resulted in a 3.62 percent significant reduction in the number of women with wages lower than men and a 6.48 percent significant increase in the number of women with wages equal to men. Improvements in wage equality are the result of increased demand for women labor for post-harvest activities due to higher yields from UDP adoption.

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