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Comparison between Irrigation Payment Systems and Probability of Using Water Saving Technology

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Abstract

This study attempts to answer two questions: Why have different payment systems for high yielding variety of Boro paddy irrigation emerged in Bangladesh? Why do some farmers apply water saving technology? Thirty shallow tubewell owner farmers and 180 user farmers were selected from two areas in Bangladesh to get representative samples of this study. Descriptive statistics and coefficient of variation analysis were used to address the first question, while an econometric probit model is used to determine the factors, which influenced the adoption of water saving technology. The results show that users in the poor and high-risk area prefer crop share. The average pay for irrigation is higher in the crop share system, thus the water selling business is more profitable in crop share system. The water saving technology is used more in the cash payment system. The probit model's results show that the adoption of this technology increases with an increase in the number of users, owners' education, cash payment system, farm size and households' income, which is logical. Likewise shallow tubewell's (STW) income, area under STW, involvement of other occupation except agriculture and irrigated area of own farm exert a negative effect on use of water saving technology. There is no universally accepted optimal payment system because systems develop and change due to mainly economic circumstances, in addition to long run localized social factors which should not to be ignored. But, the crop share system is under attack due to rising output prices and the fact that it does not provide strong incentives for water saving.

Keywords: Boro paddy, irrigation, crop share and cash payment systems, water saving technology

1. Introduction

Bangladesh is a country of South Asia where 144 million people are living on 147 570 sq. km of land area. It is the most densely populated country in the world (975 per sq. km), and has suffered from food deficiency for a long time. Agriculture is still the mainstay of Bangladesh economy accounting for about 22 percent of her GDP, about 70 percent of employment and over 80 percent of the export earnings (BBS 2006). But the sector is still characterized by low productivity. The goal of achieving self-sufficiency in food production or of accelerating economic growth cannot be realized unless agricultural productivity is increased substantially. The major challenge of the government is to increase food grain production to meet the demand of a large and growing population.

Rice is the staple food to the people of Bangladesh. Therefore policies are highly biased to producing more and more rice by introducing modern technologies like fertilizer, seed, power tiller, pesticide, irrigation, cultivation methods, etc. Boro (High yielding variety of paddy grown in dry season) rice contributed the highest share of rice production in 2007. It indicates that promoting Boro rice production is an effective way to increase food grain production of the country and it may ensure the food security to some extent as well. Irrigation covers 44 percent of total cropped area of Bangladesh. In Bangladesh, 80 percent of groundwater was used for crop production where Boro rice alone used 73 percent of total irrigation.

The STW is operated by diesel or electricity. Relatively rich farmers have their own STW and they irrigate their own land and sell water to other farmers, who are being charged a share of harvested crops or cash payment. There are some STW owners who do not have land but they are selling water to other users. In such cases, the owners installed their STWs to others' plots and the compensation was made as reducing irrigation charge (1/8 of crop share instead of usual 1/4) or free irrigation for that particular plot (Sharmin *et al.* 2008). In most cases, the share is one-fourth of harvested crops or if it is cash, it is charged per unit of land (approx. $ 210 per ha). In case of newly adopted cash payment system, STW owners get service charge per decimal basis against the use of it and users operate STW for getting water using their own fuel.

1.1 Development of irrigation payment systems in Bangladesh

The market for irrigation technologies has been largely liberalized and privatized since the early 1980s. With the expansion of STW irrigation, a competitive market for irrigation water has evolved. The main characteristic of the market is that the STW owners irrigate their own land and partners' land and sell excess water to irrigate plots of their neighbouring farmers. There are even some owners who are coming to this business for selling water only. Payment of irrigation water is made in cash per unit of land or as one-fourth crop-share or different mode of rental arrangements. As the irrigation water market is maturing with increased number of pumps installed, different pump owners pursue different strategies to run their water selling business profitably. In crop share system, STW owners collect their share from the land after harvesting crop i.e. HYV Boro. (If they irrigate well, they will receive good share and it also depends on users' practice of weeding, seedlings, use sufficient fertilizer and insecticides. Yield also depends on rainfall, flood, high speed winding in the flowering stage, etc.) On the other hand, cash payment system is basically two types: One is STW owner serves water whole season and how much cash an owner will get, depends on local arrangement between owner and user, time of payment, soil type and elevation of the plot, distance from the STW, relation with owner, etc. Another cash payment type is newly introduced cash payment system. In this system, users pay service charge for using shallow tubewell and use diesel and other irrigation management of his own. The service charge varies depending on location and contract between owners and users. There was crop share system before introducing this cash payment system. This payment system emerged due to high price of diesel and engine oil user has some more availability of cash flow. The STW owners' take less responsibility in this system and can reduce transaction cost.

1.2 Water saving technology

The concept water saving technology (WST) or a modern water-saving agricultural technology system that focuses on improving the efficient utilization of crop water, field water, channel water and recycled water, and the benefits from agricultural production; it established key products and equipment for water-saving agriculture characterized by high-efficiency, low-cost, eco- and environment-friendly advantages; and set up a water-saving development pattern suited to the different needs of different areas (WPA 2008). HYV paddy plants need water and it will suppose to be sufficient if soil is wet enough, but don't need to always have 2-4 inches depth of water in the field. Ministry of Agriculture in Bangladesh is currently implementing a project 'Alternate Wetting and Drying' (AWD) which main objective is to minimise water charge by saving water.

2. Theoretical framework and Methodology

The payment system is one kind of contract system in agriculture. The most commonly studied contract system is that of sharecropping, and the theory of sharecropping is very relevant to the payment system for water. There are three elements which are important to consider. They are: (i) the expected pay; (ii) risk sharing, and (iii) timing of payment.

In a share crop system, users are expected to pay more, but the pay depends on whether it is good or bad crop year. The general pay might be higher because the STW owner monitors production activities since he will get a share of the harvested crops. This monitoring is nothing but transaction costs of owners (Otsuka 1988). Further, STW owner invests his capital for about 5 months and he takes a risk. He may get back his investment and some extra profit or may get nothing if flood, cyclone, heavy rain, etc. are there in the harvest time. He expects premium of that high risk also. In addition to this, STW owner has to carry diesel, engine oil, driver cost and other maintenance costs for the entire crop season. He has to borrow money from bank or any other sources with high interest rate. These are the reasons for the higher pay in the crop share system.

On the other hand, STW owner takes less responsibility in cash payment system and these responsibilities and risk go to users directly. It can be seen from the following table that these 3 elements are linked with payment systems. STW owners like to choose sharecropping because it gives them higher return after harvesting. However, to get higher return they have to carry higher risk, have to bear irrigation cost during the crop season and high transaction costs (Table 2.1.1).

For the users, the picture is the opposite. Poor users may prefer the crop share system as they are more risk averse (Ellis 2003). Average pay is expected to be high in crop share system and users under crop share system are ready to pay that in order to minimise risk. In addition, they do not have cash available since they are poor. Users who have more access in credit prefer cash payment system and they can save their return more from crops by taking risk in her/his own. On the other hand, less access of credit ultimately pushes farmers to go for share cropping because irrigation cost is the major cost for producing Boro paddy along with fertilizers. Poor farmers do not have credit access due to shortage of land property. Credit institutions usually demand land as collateral for sanctioning loan to the farmers.

Water selling business is profitable and it is becoming more familiar in rural areas where farmers do not have more scope to go for other business (Sharmin 2008). It is assumed that this water selling business will be more profitable in crop share system than in cash payment system because the value of one-fourth harvested crop is much more higher than the average pay in cash payment system.

2.1 Arguments for applying water saving technology

In case of share cropping, STW owners have less scope to implement water saving technology (WST) because users are not so much motivated with this technology. Since the users did not have cost to supply water, they always demand high level of water in their plots so that they can finally harvest more. On the other hand, WST will be used more in case of cash payment system because farmers use their own fuel to get water in their plots and they always use as minimum water as rice plants needed. Farmers are self-motivated in this system and high fuel price also chase them to implement this WST for watering in their plots.

2.2. Literature reviewed

The groundwater markets had far reaching social effects. Some 5-7 million well owning rural families in India were likely to be involved as water sellers; some 15-25 million or more would be water buyers. Where land holdings were fragmented, most sellers of water were also buyers themselves; for most farmers made wells in one or two of their largest and best fragments plots, and often use purchased water for irrigating the other plots (Shah 1989).

The share crop system observation was the main attempt of the study. The study observed that the threat of encouragement caused water suppliers to revert to cash payment system to share payment system and the water suppliers gave a bonus irrigation to the water buyers' plots getting future commitment of the water buyers (BSERT 1984).

Contractual arrangement for use of ground water were: irrigation to the cultivated land owned by tubewell owners (35 percent of land); irrigation to land that tubewell owners cultivate seasonally as tenants (42 percent) and sale of water (24 percent). It was concluded that groundwater market was competitive and efficient (Fujita 1995).

There are generally two major forms of payments for water under DTW and STW. The first is the traditional system of fixed cash payment per unit of land or time usually based approximately on the average cost of supplying water including fuel, management and supervision. Payment is made partly at the beginning and partly after the harvest of paddy. The other system which is widely practiced is the payment for water in the form of a 25 percent share of the harvested crops (Shah 1989).

The above literatures focused on the profitability of schemes, efficiency of tubewells in terms of command area, determination of optimal cropping patterns, irrigation efficiency, water market status, etc. A number of studies were conducted on the comparative analysis of shallow tubewell irrigation under different management systems in respect of productivity but very few of them focused on mode of payment of irrigation, linkages of irrigation technologies, water saving technology and their impacts on farmers' income.

The present study is taken to explain why two different payment systems for irrigation emerged in the study areas and why some farmers go for water saving technology.

2.3. Research questions

The specific research questions are noted below:

i. Why have different payment systems for irrigation emerged in the study areas? ii. Why do some farmers go for water saving technology and which factors influence them to introduce WST?

2.4. Hypotheses

The specific hypotheses are as follows:

i. Users in poor area prefer crop share;ii. Average pay for irrigation is higher in crop share system; iii. Areas in high risk go for crop share system; iv. Areas in less credit access lead to go for crop share system; v. STW irrigation business is more profitable in crop share system; and vi. Water saving technology will be used more in cash payment system.

2.5. Data and Methods

The analysis has been done based on data collected from a sample of STW owners and irrigator farmers. The structured questionnaires and survey schedules were used to collect the data in June-July 2007. A 60 sample of STWs owners and 180 farmers were selected in a cluster from an intensively irrigated area in the two districts (Tangail and Mymensigh) of Bangladesh. Descriptive statistics have been used to explore why there are two payment systems in the study areas, whereas a Probit model is used to determine factors influencing adoption of water saving technology (Rahman 2008).

2.5.1 Study approach

2.5.1.1 Two sample test

The analysis is done based on households (hhs) of two areas. Households in the sharecropping and cash systems are compared with respect to the mean of the hh characteristics and socioeconomic variables. It is reasonable to use two samples test to compare the two categories given the completely randomized nature of the samples (Montgomery, 2000). It is assumed that the data for two samples consisted of two independent samples defined $Z_1, Z_2 \ldots Z_n$ and $A_1, A_2, \ldots A_n$. Here it is also assumed that both Z_n and A_n are normally distributed (NID). Two samples t-test is used to evaluate the null hypothesis Ho: $\mu_Z = \mu_A$. The null hypothesis is rejected where critical t-value is greater than the calculated t-value.

2.5.1.2 Coefficient of variation (CV) analysis

Coefficient of variation is used to measure risk of productions and prices in agriculture. It is unit neutral. Production risk can be measured using yield variation between the areas. If CV ratio is higher in an area of a particular crop than other area it means the area has more risk to produce that crop.

$$CV = \frac{\sigma}{\mu} = \frac{\text{standard deviation}}{\text{mean}}$$

2.5.1.3 Econometric model specification

General structure of an econometric model is written as follows:

$Y_i^* = X_i\beta + \mu_i$

Where Y_i^* denotes the dependent variable and X denotes the independent variable of the model which determine the Y but not 100 percent. To explain Y 100 percent, μ is used as an error term and it is assumed that $\mu_i \sim N(0,1)$.

The binary-choice models can be used in Stata with the commands probit and logit. Stata probit command reports the maximum likelihood estimates of the coefficients. Dprobit is useful to display the marginal effect $dPr(y = 1|x)/dx_j$, that is the effect of an infinitesimal change in x_j. Using probit this way does not affect the z statistics or p-values of the estimated coefficients. Because the model is nonlinear, the df/dx reported by dprobit will vary through the sample space of the explanatory variables. By default, the marginal effects are calculated at the multivariate point of means. After fitting the model, mfx can be used to compute the marginal effects. A probit estimation followed by mfx calculates the df/dx values. After fitting a probit model, the predict command with the default option p, computes the predicted probability of a positive outcome. Specifying the xb option calculates the predicted value of y_i^*.

In this study, the probability of using WST is firstly depended on sharecropping and cash payment systems. Secondly, it depends on agricultural income, other income, farm size, education, family size, number of users, STW command area, etc.

3. Results and discussions

3.1 Households' characteristics

Most of the household indicators of the two study areas are quite similar except the family size and the occupational status of the respondents and their family members. The owners' family size (6.3) is bigger than the users'. Most of the respondents (more than 90 percent) are involved in agriculture, and other major occupations are business and service.

The figures in the table 3.1.1 show that average farm size of STW owners are greater than average farm size of the users. It is also seen that farm size of the owners of the Ghatail area (CSS) is very high among the all categories of payment systems and statistically significant between the two categories of payment system.

In Bangladesh irrigation covers about 50 percent of total cultivated area but more intensive irrigation is found in these two study areas. About 75 percent area is under irrigation system. The owners use more percentage of their land (88%) in irrigated crops under crop share system than the owners under the cash payment system (70%). On the other hand, users of the cash payment system use more area (81%) to produce irrigated crops than the users under the crop share system (73%).

3.2 Income from crops

Actual income from agricultural crop production is the difference between return from crops and cost of producing those crops. The incomes of owners under crop share and cash payment system are $240 and $603, respectively. On the other hand, the incomes of the users in both areas are $195 and $223, respectively. It can be concluded that the farmers of the crop share area are relatively poor than farmers of cash payment area. In figure it is more cleared that the average income of the users under CS is higher than CP system (Table 3.2.1).

Income level from the major crops showed that the incomes of the owners and users under crops share system are less than the incomes of the cash payment system. These differences are statistically significant. This also indicates that the area where crops share system practised is relatively poorer than the cash payment system in practicing area.

3.3 Other household's asset

It was an initiative to estimate the other HHs' income of the STW owner and user of the study areas. Here other income means income other sources than crops. The average other income (livestock, fishery, service, business, wage income and remittance) of the STW owner ($684) in the crop share system is higher than cash payment system ($472). The opposite trends are found between the user farmers and they were $507 and $397, respectively. It is seen from the table that the highest share of STW owner is the income from water selling business. On the other hand the highest share of users' farmers of CS and CP systems are income from livestock/service and business, respectively.

So, from the above data and discussion, it can be concluded that the area under crop shared system is poorer than area under cash payment system in terms of income from crops, other HHs' income, HHs' permanent assets and house asset which supports the hypothesis 1: "Poor user prefers crop share". Farmers in poor area are risk averse and they will share risk with owner and it will allow continuing crop share system.

The table 3.3.1 describes that per HH average pay for irrigation is higher in crops share system ($102) than cash payment system ($76). The differences of irrigation cost between two categories are statistically significant at 1 percent level of significance. It is also observed that per hectare average pay for irrigation in crop share system is higher ($257) than cash payment system ($156). These differences are also statistically significant at 1 percent level of significance.

The above table and statistical analysis clearly indicate that if farmers choose crop share system, the users have to pay more compared to cash payment due to high transaction cost, late payment and sharing risk with STW owners. So this analysis supports the hypothesis "Average pay is higher in crop share system" of this study.

3.4 Focus group discussion (FGDs) in Ghatail and Muktagacha

Two FGDs have been conducted in the study areas to get the overall picture of heavy rainfall and flood of these two areas. The FGD was done mainly to know the crop damaged by the heavy rainfall and flood. The farmers reported that the HYV Boro was affected seriously due to early flood in 1988, 90 and 1998. Heavy rainfall in April/May was a problem for their crop in 1994, 2003 and 2006. T-Aman was affected more and frequently because this crop was planted before monsoon and it grew at peak period of monsoon. In 1988, 1990, 1998 and 2007, there were almost no T-Aman crop in that area due to flood and heavy rainfall. On the other hand, Muktagacha was flooded only in 1988 and also flooded little bit in 1998. There were some rainfall but it was not actually heavy in the last 15 years except heavy rainfall in 1994 and 2006.

3.5 Coefficient of variation analysis of yield

The most important and widely produced crops are Boro and Aman paddy in the study areas. Coefficient of variation analysis shows that the CV of Boro yield in Ghatail area under crop share system is greater (0.82) than that of Muktagacha area (0.47). The same trend is noted between the CVs of users in both payment systems respectively (Rahman, 2008). It is also seen that the trends of Aman paddy's CVs are same direction as the previous case. In the case of STW owners, the CV of Aman paddy yield under crop share system is extremely higher than that of cash payment system. The CV analysis of Boro and Aman paddy shows that the area under crop share system is risk lover than the area under cash payment system (Table 3.5.1).

The Center for Environmental and Geographic Information Services (CEGIS) is working with Radar ScanSAR image and it is easily readable of flooded and non-flooded areas of a place. The dark areas of in the following figures show the flooded areas. The Radar images of flooded and non-flooded area of Ghatail and Muktagacha shows that Ghatail area has more flood areas than Muktagacha areas which is quite similar with the opinions of the local people.

It can be concluded from the above discussion that Ghatail area where crop share is practised is more risky to grow crops particularly HYV Boro and T-Aman due to frequent flood and heavy rainfall. On the other hand, Muktagacha where cash payment system has emerged is less risky for producing HYV Boro and fishery due to abundance of high land. The image from RADAR and discussion from FGD strongly support the hypothesis, "areas in high risk go for crop share system".

It is seen from the study that 58 percent of STW owners and 53 percent of users are getting credit facilities. Among them 40 and 32 percent are getting loan from government institutes like Bangladesh Krishi Bank, Sonali Bank Ltd. etc. Others are taking loan from NGO and relatives where the interest rate is very high (26-28 percent) compared to GO (12 percent). Farmers have less scope to get credit in Ghatail upazilla where farmers are practising crop share system. It is observed that the users in Ghatail area is getting $65 loan per HH whereas in Muktagacha, they are getting $143 per HH and this differences are significant at less than 1 percent level. It is due to backwardness of the location and long distance from the district town. It is also found that the variation between average GO and NGO loan are statistically significant between two places under two payment systems. The respondents reported that they are facing serious problems about loan due to insufficient collateral, high interest rate in the NGO level, long time period of getting loan, insufficient amount of loan and bureaucracy in loan sanction particularly in government institutes.

Credit availability allows farmers to have cash flow in their hand. If they have more cash flow, they will choose the system in which they have to pay less otherwise they have to pay more. It is already discussed that in crop share system, users have to pay more than cash payment system. Farmers of Ghatail area are not getting credit facilities sufficiently due to backward location factor. On the other hand, farmers are getting more facilities to have credit at Muktagacha. It may be a reason to practise cash payment system in Muktagacha upazilla. Descriptive and statistical significance test clearly support the hypothesis, "Areas in less credit access lead to go for crop share".

In crop share, owner has to bear all costs for watering the plots. Diesel cost is the highest (65 percent) in crop share system. On the other hand, per year equipments cost of STW is the highest in cash payment system and owner has to incur limited amount of cost (only 34 percent of crop share cost) for watering others' plot. Farmers share risk in crop share system and STW owners get their share at the end of the season that is why they get more return which is about $367. This return is higher compared to return of cash payment system. Undiscounted benefit cost ratios show that crop share system gives higher return than cash payment. Profit per hectare shows that the profit in crop shares system is about 5 times higher than the profit of cash payment system. To get this high profit, the owner in the crop share system has to invest more money (66 percent higher than cash payment) and has to take more risk compared to cash payment system. It can be concluded that the return in crop share system is statistically higher than that of cash payment system.

The above discussion is about water selling business. It is observed that water selling business is more profitable in crops share system than in cash payment system. STW owner will prefer crop share system for making high profit, which captured hypothesis, "STW irrigation business is more profitable in crop share system".

Water saving technology is a new concept and it came about due to shortage of groundwater and due to high increase in fuel prices. HYV Boro needs water to grow well, but farmers are using lot of water in their field. If farmers put water that ensured that the soil is wet, this would be sufficient for HYV Boro (i.e., do not need to flood the field with water). Usually farmers who do not know how to use more than 4 to 6 inches water in their field. Their arguments are if they have high level of water in the plot, they do not need to give water everyday and weeds cannot grow in high-level water level in the crop field. The problems with those arguments are that water evaporates under high temperature and it also leaks out to neighbouring plots. If farmers use optimum water continuously, it will also be effective for growing fewer weeds although it needs more driving cost. But research ensured that WST is still more economic for the resource poor farmers.

The STW owners in cash payment system use more WST (60 percent) than owners under crop share system (23 percent) and users in crop share system use less WST (14 percent) than cash payment system (39 percent). The differences are statistically significant at 1 percent level of significance. The most likely reason is that it is less common in the crop share system because users do not pay directly for the cost for supplying high level water. It is also difficult for owners to take care of all plots' water level. Besides users always make pressure to have more water in their plots because they are not so aware of WST and its broader future impacts. It can be concluded from the above discussions that users under cash payment use WST more than crop share which is nothing but the hypothesis, "Water saving technology will be used more in cash payment system".

The table 3.5.2 summaries the relative scope for adopting payment system based on risk, credit, discount rate, transaction cost, soil type and work diversification in the two study areas.

3.5.1 Econometric estimation results

A probit model is estimated to explain the decision to practise water saving technology as a function of owner's income from shallow tubewell (STW), education, payment system for irrigation (ca), occupation category (oc), hh's size (hhsize), farm size (farmsize), irrigated land (irrih), income (hhincome) and credit facilities (hhtdamount).

The results are plausible and theory consistent as the coefficients possess the expected signs. Significant F-statistics or Chi^2 shows that the overall fit of the model is good. The results shows that application of water saving technology increases with the increases in number of users, owners' age, education, cash payment system, farm size and hhs' income. WST application increases with an increase in number of users and also increases with the category of owners' occupation. The increases are statistically significant at 1 percent level of significance. Owners have to distribute water among all users and in that case owners have to be careful about the volume of water. Owners who are involved in other occupation than agriculture, they apply more WST because they have higher education and have access to more information. WST use increases with the increase size of irrigated area and owners' age and depends on which payment system they used. The figures are also statistically significant at 5 percent level. Irrigated area under a STW is related to number of user of that tubewell. They have to supply optimum water if the command area of a STW is large. Owners in cash payment system apply more WST. Likewise STW income, area under STW, involvement of other occupation except agriculture and irrigated area of the households exert a negative effect on accepting water saving technology (Table 3.5.3).

In the case of users, a probit model is fitted with the decision to apply water saving technology depending on users' age, education, payment system for irrigation (ca) and occupation category (oc) used as dummy, hh's size (hhsize), farm size (farmsize), irrigated land (irrih), income (hhincome), hhs' resource income (hhrincome) and credit facilities (hhtdamount). The analysis shows that the model is fitted well (24.58***). Here Pseudo R^2 is 0.1336 and log likelihood is -90.435 (Table 3.5.4).

The results are also consistent with relevant theory as the variables' coefficients possess the expected signs in users' case also. Application of water saving technology is higher in the cash payment system, and is increasing with HHs' size, irrigated area and income from crops. Payment system and size of irrigated area have significant impact on applying WST, and is significant at 1 percent level. User will use less water in cash payment system because they have to operate STW with their own diesel. A large farmer with large irrigated area has to use more WST because he has to irrigate all his land with his own diesel. He will use diesel economically, which ultimately lead him to adopt WST. Further, users' education, other occupation than agriculture, farm size, hhs' resource income and credit access has a negative effect on application of water saving technology.

4. Conclusions and recommendations

There are two different payment systems in two study areas. In Ghatail, the crop share system is practised, while in Muktagacha the cash payment system is found. Farmers in Muktagacha reported that they also had a crop share system, but they introduced cash payment system because the users always complained that they did not get sufficient water in their plots timely. It was mainly due to higher diesel price. The STW owners' views are quite different. They reported that the users always demand more and more water in their plots, but they never consider that the plot is in high altitude land, the soil is sandy, weather is dry, the plot is far away from the source of water, etc. They also thought that there are some risk factors to get good crops. Instead of those risks they now get cash return for their machine and users can take as much water as they need by using their own labour and fuel in cash payment system. It also reduces transaction cost, operating cost, and conflicts between owner and user. In the Ghatail area, on the other hand, users are poorer, have less credit facilities, and the risk is high. Users want to share their risk. The land is low, the soil type is clay, and it is easy for owner to water the land regularly. Risk is high due to flood and heavy rain, but if it is good crop year, they can get high return and they have social influences on users to make sure the use of sufficient inputs. These findings are in line with the theory, which suggest that poor farmers (Ghatail) are more risk averse and they will prefer to share risk and that is possible only in crop share system. On the other hand, users in Muktagacha are richer, have more credit access and risk is lower, and they will prefer cash payment system.

From the owners' point of view, the owners in Ghatail found water selling business profitable and they are used to share risk and the users do not have so many complaints about the delivery of water in their plots. They prefer the crop share system. On the other hand, owners in Muktagacha invest less, share no risk, bear less transaction costs and get payment in cash. Two systems developed in the two areas due to differences in economic and ecological conditions. There is no universally optimal payment system because systems develop and change due to mainly economic and ecological circumstances, in addition to long run localized social factors, which should not to be ignored. However, the crop share system is under attack due to rising output price and due to the fact that it does not provide strong incentives for water saving.

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Table 2.1.1: Important elements linked with payment systems

Contract element	Crop share	Cash payment
Expected pay	High	low
Risk sharing - user - for owner	 Medium High	 High low
Timing of pay	Late	Early

Table 3.1.1 Per household's land distribution patterns of the study areas

Sl.	Land type	STW Owner (N=30+30)	STW User (N=90+90)

No.		Crop share	Cash payment	Average	Crop share	Cash payment	Average
1.	Homestead area	0.07 (0.04)	0.09 (0.05)	0.08 (0.05)	0.06 (0.05)	0.07 (0.05)	0.07 (0.05)
2.	Own cultivated land	0.52* (0.46)	1.14* (1.06)	0.85 (0.88)	0.41** (0.44)	0.55** (0.48)	0.49 (0.46)
3.	Rented in land	0.25 (0.21)	0.69 (0.62)	0.35 (0.37)	0.30 (0.18)	0.23 (0.11)	0.29 (0.18)
4.	Rented out land	0.67 (0.67)	0.37 (0.32)	0.55 (0.56)	0.78 (0.61)	0.57 (0.29)	0.75 (0.57)
5.	Mortgaged in land	0.36 (0.21)	0.16 (-)	0.34 (0.21)	0.27 (0.21)	0.25 (0.13)	0.26 (0.18)
6.	Mortgaged out land	0.37 (0.33)	0.67 (0.31)	0.48 (0.32)	0.08 (0.05)	0.28 (0.17)	0.18 (0.16)
7.	Farm size	0.49* (0.40)	1.20* (1.04)	0.81 (0.84)	0.48** (0.29)	0.53** (0.39)	0.50 (0.34)

Note: Figures in the parentheses indicate the standard deviation of the value of the respective items.
*Statistically significant at 1% level of significance
**Statistically significant at less than 10% level of significance

Table 3.2.1 Per household's income from crop production of the farmers in the study areas

Sl. No.	Item	STW Owner (N=30+30)			STW User (N=90+90)		
		Crop share	Cash payment	Average	Crop share	Cash payment	Average
1.	Return from major crops ($)	542	1191	866	476	553	514
2.	Cost of production ($)	302	588	445	281	330	305
3.	Income from crops ($)	240*	603*	421	195**	223**	209

Note: * significant at 1 percent level and ** significant at 5 percent level

Table 3.3.1 Per households and per hectare average pay for irrigation in the study areas

Cost item	**Crop share**	**Cash payment**	**Average**
Irrigation cost/HH	102* (66)	76* (53)	89 (61)
Irrigation cost/ha	257* (159)	156* (40)	206 (126)

Note: Figures in the parentheses are standard deviation
*Significant at 1 percent level of significance

Table 3.5.1 Per hectare yield of Boro and Aman paddy of the study areas

Sl.	Crops	Unit	STW Owner (N=30+30)	STW User (N=90+90)

No.			Crop share	Cash payment	Crop share	Cash payment
1.	HYV Boro	Yield (kg/ha)	6683 (5447)	5302 (2492)	6467 (5198)	4987 (3571)
2.	CV of Boro yield	-	0.82	0.47	0.80	0.72
3.	Aman/ T-Aman	Yield (kg/ha)	2495 (2537)	3510 (2156)	1620 (1359)	2774 (1114)
4.	CV of Aman yield	-	1.02	0.61	0.83	0.40

Note: Figures in the parentheses are the standard deviations.

Table 3.5.2 Relative scope of different indicators in the study areas

Name of area	Risk	Credit availability	Discount rate	Transaction cost	Soil type	Work Diversification	Adopted system
Ghatail	High due to flood, heavy rainfall	User farmers have less access to get credit	High (prefer to pay later)	High in crop share system	Crops in clay soil need less water	Low	Crop share
Muktagacha	Low	More access	Low (prefer to pay early)	Low	Crops in clay sand soil need more water	High	Cash payment

Table 3.5.3 Estimated probit results (STW Owners' case)

Variable	Description	Coefficient	Robust Std.	Z	P>Z

		(dy/dx)	error		
stw	Income from water selling business	-0.002	0.003	-0.80	0.424
nstw	Number of users of a STW	0.027***	0.011	2.47	0.013
astw	Area under STW	-0.006	0.057	-0.10	0.921
age	Age of the STW owner	0.006**	0.006	1.03	0.303
education	Owners' education	0.048*	0.028	1.76	0.082
ca	Dummy for payment system (0=crop share 1=cash payment)	0.607**	0.262	2.32	0.020
oc	Dummy for occupation (0=agriculture, 1=other than agriculture)	-0.342***	0.140	-2.44	0.015
Farm size	Farm size of the HH	0.033	0.214	0.16	0.876
irrih	Irrigated area of the HH	-0.378**	0.182	-2.07	0.038
hhincome	Income from crops	1.60e06	0.0001	0.01	0.990
R2 or Pseudo R2		0.3297			
F-statistic or Chi2(10)		21.23***			
Log likelihood		-26.367			
Number of observations		58			

*** Significant at 1 percent, ** at 5 percent and * at 10 percent.

Table 3.5.4 Estimated probit results (STW users' case)

Variable	Description	Coefficient (dy/dx)	Robust Std. error	Z	P>Z
education	Users' education	-0.005	0.012	-0.43	0.669
ca	Dummy for payment system (0=crop share 1= cash payment)	0.256***	0.069	3.69	0.000
oc	Dummy for occupation (0=agriculture, 1= other than agriculture)	-0.028	0.100	-0.28	0.777
Farm size	Farm size of the HH	-0.290**	0.144	-2.04	0.041
hhsize	HHs' size	0.0006	0.025	0.03	0.980
irrih	Irrigated area of the HH	0.490***	0.154	3.19	0.001
hhincome	Income from crops	0.00004	0.00006	0.63	0.527
hhrincome	HHs' resource income	-0.00004	0.00003	-1.26	0.209
tdamount	Credit availability	-0.00009	0.0002	-0.41	0.680
age	Age of the users	-0.0017	0.0025	-0.67	0.502
R2 or Pseudo R2		0.1336			
F-statistic or Chi2(10)		24.58***			
Log likelihood		-90.435			
Number of observations		180			

*** Significant at 1 percent and ** at 5 percent.