Bangladesh Journal of Political Economy

Vol. 31, No. 3, June 2016, pp. 151-170
Bangladesh Economic Association
(ISSN 2227-3182)

Determinants of Rice Production Inefficiency in Groundwater Irrigation Markets in Bangladesh

Rahman, M. Saidur*
Mandal, M. A. Sattar*
Kajisa, Kei*
Bhandari, Humnath*

Abstract: *Total foodgrain production in Bangladesh is 32.9 million tons of which boro rice is 18.78 million tons. Boro rice is produced by using mostly groundwater (80%). In this paper, our aim is to see the* variation of yield*,* irrigation hours use*, and labour use under different* payment systems *and land tenancy situations. It also highlights the difficulties of supervision, commitment and transaction cost on the use of irrigation and labour uses. Ninety six villages were selected from five divisions of Bangladesh following multi-stage sampling and data were collected through FGD and personal interview methods from 960 households. Simple OLS method is used to estimate the factors influencing the yield in irrigated rice production. The tabular and model analyses show that the variations of yield, irrigation and labour uses are different depending on the* payment systems *and land tenancy categories. Models show the same indications regarding* supervision and commitment issues *of providing irrigation water to the users' plot both in crop share payment and share cropping system. Among all the payment systems, crop share and fixed charge payments have resource allocation problem of irrigation water and labour uses and it may be also true for the other inputs use. This problem can't be improved so much like in the land tenancy market by the users through providing only transaction cost because they have no strong instruments. It is seen from the tabular analysis that the fixed charge system is less viable since there is more scope to be refused irrigation water when there is scarcity of water, high price of diesel, bad relation between user and seller and limited cash flow to sellers in the pick time of rice growing since that time crop needs water more frequently. The two part tariff has fewer demerits than both of*

* Professor & Head, Department of Agricultural Economics, Bangladesh Agricultural University, Mymensingh; * Professor, Department of Agricultural Economics & former Vice-Chancellor, Bangladesh Agricultural University, Mymensingh; * Professor, School of International Politics, Economics and Communication, Aoyama Gakuin University, Japan; * Agricultural Economist, International Rice Research Institute (Bangladesh Office), Dhaka.

crop share and fixed charge payment systems since the user use own diesel and labour for managing water by using tubewell. But the limitation is the scope of getting of access the tubewell in two part tariff system because other users are on queue for using tubewell.

Key words: Production inefficiency, groundwater irrigation, transaction cost, supervision cost.

Introduction:

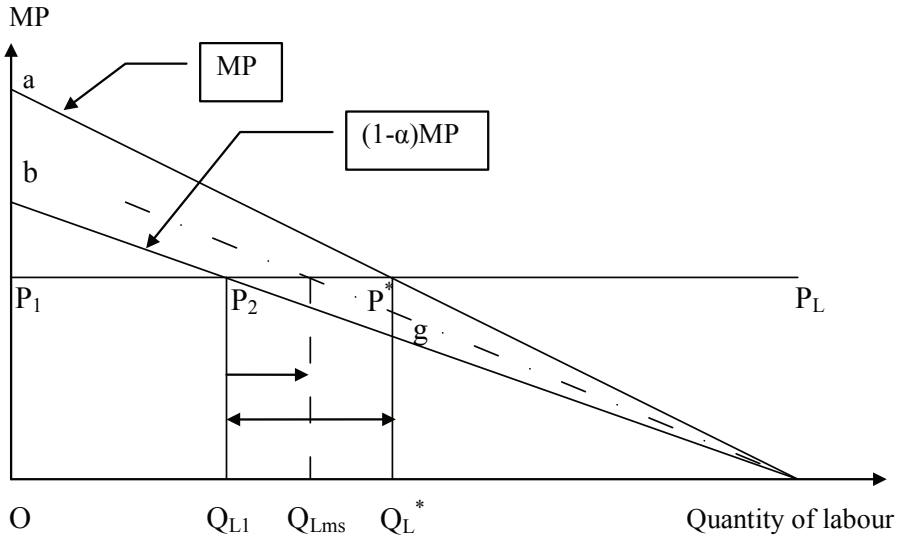
Allocative inefficiency for crop share payment in irrigation

In land rental market, landlord provides land and tenant provides labour, capital and management inputs but land is the scarcest input to the tenant. The tenants always try to maintain a good relation with landlord at any cost so that they can get the use right of land for a long time. But in water market, buyers use all sorts of input except water. Only to provide water to buyer, a seller may not be in a position to motivate one to use other inputs sufficiently. Question may arise that one may also lose the use right of water for the next season like land use right. Due to the availability of cheap irrigation technologies in the market, the numbers of seller are increasing and the buyers may have alternative seller to get water. This opportunity was very limited in the previous time but it is now becoming easy to buyers. So buyers have less binding to listen to sellers' suggestions; rather the buyers keep pressure on sellers to provide water regularly and sufficiently, otherwise they may leave the tubewell in the next cropping season.

Another thing is the priority issue to deliver water to the seller's parcels first. It is found that most of the tubewell owners buy tubewell mainly to irrigate their own parcels and sell water to other buyers for maximizing profit. It is observed that in a command area of a shallow tubewell, 50-60 percent of land is owned by the seller and 40-50 percent sell was to others' land. The seller's priority is to deliver water in his own parcels first and later s/he provides water to the buyers' parcels. Timing of watering and sufficient amount of water in every delivery is very important for rice crop but the sellers are reluctant to provide water for buyers' parcels. On doing this, sellers usually lost their moral courage to monitor and supervise buyers' activities regarding other inputs use. This situation is hardly found in land rental market due to its nature. In some cases, because of the experience of having less commitment of seller to provide water regularly and sufficiently, the buyers fail to use other inputs like human labour and fertilizer at the later part of the production process, which leads ultimately to lower productivity of that parcel. So, inefficiency issue in irrigated crops remains as it was and we get lesser yield as a whole from the buyer's parcel. Still a question may arise, why inefficiency will be there as long as it is owner cultivated land? The answer of this issue is simple if we compare it with share tenancy in land rental market i.e. input sharing is there. So due to

haveing irrigation input from anyone else, water sharing land cultivation will be treated as tenant cultivated land. We can say water tenant cultivated land and obviously the inefficiency of crop production will be there.

The inefficiency situation may be explained better by the following conventional diagram of share contracts which illustrates Marshallian inefficiency (Hayami & Otsuka, 1993; Otsuka & Hayami, 1988). The X axis indicates quantity of labour and Y axis indicates the marginal productivity of labour. It is assumed that the wage rate of labour is fixed and labour use varies depending on how much a tenant gets as a share.



In normal situation, farmers who have their own tubewells use OQL* amount of labour with the wage of P*QL*. In crop share irrigation, buyer gets share or part of MP which is (1 - α) MP at the end of crop harvest. Due to that, it is expected that like share cropping in land rental arrangement the buyer will use OQ_{L1} amount of labour and production inefficiency will be there under no supervision and enforcement situations. If monitoring and supervision are there from seller side, there is a possibility to increase labour use up to QLms. (Johnson, 1950; Cheung, 1969; Hayami & Otsuka, 1993). Since monitoring and supervision on buyers are not so strict and effective in water market, the labour use increase may not be the case here which has happened in the land rental market.

The productivity of land depends on input use but it also depends on commitment level between seller and buyer in irrigated rice farming. The commitment level varies due to the variations of payment system. In cash payment system, the return for water supply is ensured because payment for water is made at the beginning of the season. Meanwhile crop share payment entails uncertainty of getting payment

of water. This means that the 'risk of default of payment' is higher under crop share contract. Drought is a very normal phenomenon in boro rice production season. In drought situation, water is usually very scarce in some rice growing areas. The risk arises also due to the unexpected increase of diesel and electricity price as well. Under crop share contract if the sellers somehow notice during the season that they may not get return from supplying water due to the bad crop year (risk of default of payment), they may stop to supply water to the buyer's parcel. Under high risk of default, those factors ultimately made seller less committed to water buyer's parcel under crop share system. Our focus is the allocation of groundwater irrigation in producing HYV boro production under different payment systems. As discussed above, it is assumed that the HYV boro rice production will be increased through the use of more irrigation water under crop share payment system which is similar to land tenancy market under share cropping tenancy system. Several studies (Otsuka & Hayami, 1988; Hayami & Otsuka, 1993; Cheung, 1969) showed that production can be improved by incurring transactions cost by the land owner. There is an attempt to check it in irrigation water market as well.

Methodology:

A multi-staged sampling technique was employed to select a representative sample in this study. Five divisions were selected since they are the major rice growing divisions in Bangladesh. Forty eight upazillas were selected proportionately from the total rice areas of those five divisions. Unions and villages were selected randomly from the list of those. Then ten irrigated rice growing households were selected randomly from every village. Data were collected using structured and validated questionnaire administered on the farm families using Surveybe CAPI software during the 2013 boro rice season by trained enumerators under the supervision of the researchers. Data were collected on the socioeconomic characteristics of the farmers, production activities in terms of inputs, outputs and their prices. In this study, two hypotheses were tested. These are as follows:

Hypothesis 1. The more difficulty in monitoring and supervision of buyer's farming irrigation, the more inefficiency in production under crop share payment.

Hypothesis 2. Productivity and efficiency are lower due to less commitment and management under crop share payment.

Here we assume that the irrigation water market is somehow competitive and competition is increasing over the years due to the increasing number of tubewell owners. It is also our perception that the crop share and fixed charge payments are inefficient and less profitable for the users as many studies made similer conclusions. The source of inefficient irrigation market is due to the payment systems. In individual farmer's level, we have 4 payment systems, i.e. a. Own payment, b.

Crop share, c. fixed charge and d. Two part tariff. All these are fixed at individual farmer's level. Among all the payment systems, crop share comes up with more inefficiency, which may be due to the lower production per area compared to other systems.

To make it consistent, let us assume that we have farmers who are producing HYV boro rice in their land by using groundwater irrigation. For having water in their land they have to pay irrigation charge to the tubewell owner. Here we need to clear one thing that the tubewell owners are also the users of their own tubewell and they pay themselves for irrigation water. The production functions are identical for all those categories of farmers under different payment systems and characterized by the constant return to scale. Factor endowments, labour and irrigation water, are assumed to be different among different categories of farmers. For making it simple, we emphasise here two inputs–labour and irrigation. We measure labour in man-days and irrigation in hours. We also use other relevant inputs in the model for explaining the production function well. Our production function is written as

$$Q_i = F(L_i, I_i) \quad (1)$$

Where Qi = output per hectare

I = inputs provided by the farmer i under different payment systems.

L_i = Labour (man-day) per hectare, I_i = Irrigation (hour) per hectare, and

F exhibits production function with positive first and second derivatives (F_1,F_2>0; F_{11}, F_{22}<0). Farmers maximise productivity by using labour and irrigation along with other factors of production, which are assumed to be constant in this model. The specific model is as follows:

$$Q_i = \alpha_0 + \beta_i X_i + \epsilon_i \quad (2)$$

Where Qi is output per hectare of the farmer i in a season

X_i are labour (man-day/ha), irrigation (hour/ha), seed (kg/ha), tillage (hour/ha), chemical fertilizer (kg/ha), other fertilizer (kg/ha), insecticide and herbicides (kg or lit/ha), crop share dummy (1=crop share, 0=otherwise), fixed charge dummy (1= fixed charge, 0=otherwise), two part tariff dummy (1= two part tariff, 0=otherwise)

Socioeconomic and socio-demographic factors

X_{1i} are main soil type dummy (sandy loam) (1= sandy loam, 0=otherwise), main soil type dummy (clay loam) (1= clay loam, 0=otherwise), main soil type dummy (clay) (1=clay, 0=otherwise), main land type dummy (medium high land) (1= clay, 0=otherwise), main land type dummy (high land) (1= high land, 0=otherwise),

farm size (hectare), family kinship (1=yes, 0=otherwise), household head education (years of schooling), irrigation source distance (meter)

and, ϵi is error term which has two parts v_i and u_i. Vi is exogenous error which occurs due to the unobservable factors and u_i is for the observable factors but have not been captured by the model here.

Inclusion of supervision from seller:

$$Q_i = \alpha + \beta X_i + \gamma Z_{1i} + \epsilon_i \quad (3)$$

Where, X_i = As before

Z_{11} = Crop share payment*No. of supervision by the seller

Z_{12} = Fixed charge payment*No. of supervision by the seller

ϵ_i is the sum of two error terms

Inclusion of commitment from seller:

$$Q_i = \alpha + \beta X_i + \gamma Z_{1i} + \theta Z_{2i} + \epsilon_i \quad (4)$$

Where, Xi = As before

Z_{1i} = As before

Z_{21} = Crop share payment*Likelihood percent of refusing irrigation water by the seller

Z_{22} = Fixed charge payment*Likelihood percent of refusing irrigation water by the seller

ϵ_i is error term

Inclusion of transaction cost in land tenancy markets with irrigation water markets:

$$Q_{il} = \alpha + \beta X_i + \gamma Z_{1i} + \theta Z_{2i} + \gamma W_{1i} + \epsilon_i \quad (5)$$

Where, X_i = As before, Z_{1i} = As before, Z_{2i} = As before

W_{11} = Share price dummy*Times talk by the user-seller)

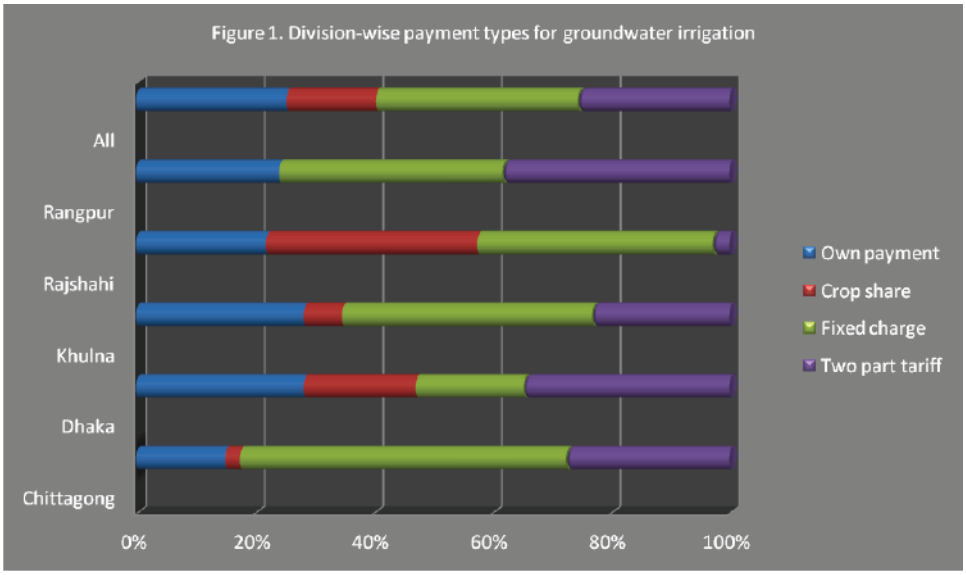
W_{12} = Fixed price dummy*Times talk by the user-seller)

ϵ_i is the sum of two error terms

Descriptions of the major variables and socio-demographic factors:

We have two forms of presentation and explanation of our survey data on irrigation water markets in Bangladesh. There are some results from the tabular analysis and some from econometric models as well.

The average age of the respondents is below 50 years and the education level is 5. It means they have 5 years schooling education. The average family size is 4.8 which is almost closer to the national average (4.7). The average farm size is the highest in Rangpur division and is the lowest in Chittagong division. Overall farm size in the country level is about 0.46 hectare. HYV boro mostly grows in 4 types of soil. The percent share of sandy loam soil is the highest (32.5%) and the clay loam is the lowest (14.8%). Loam and sandy loam are more in Chittagong division. Clay loam and clay soil are more in Khulna and Rajshahi divisions. It is seen that where the farmers' lands are medium low, they grow more HYV boro rice. Low land is good for irrigation but the risk is heavy rain and flood also. Medium high land is not good for providing irrigation but it depends on soil type also, whether it is suitable for boro rice or not. High land is not suitable for boro production at all since supply of irrigation is really difficult in the high land. Tubewell owner and user of irrigation water usually live in the same village but still their home distance is around 400 meters. Most of the largest plots are around 200 meter away from the irrigation water source (tubewell).



In this household survey data, there are actually four types of payment systems i.e. own payment, crop share, fixed charge and two part tariff. Own payment is not really a payment system but we call it because we have 242 tubewell owners who are not supposed to pay to any other for irrigation. It is not wise to exclude; otherwise their profit from own plot will be over-estimated. It can't be a particular payment since it is own pay and there is nothing more specified. In our data set, we have included it because we need to see the payment issue from both user and seller perspectives. It is seen that the fixed charge payment type is the most common practice by the farmers as payment in the groundwater irrigation market. Two part tariff is the next to fixed charge. The crop share payment is the one which

is the oldest but it is somehow becoming less popular among the irrigator farmers. It is revealed from table 1 that the crop share and fixed charge payment systems are dominant in Rajshahi division. Two part tariff is dominant in Dhaka division but the farmers of Rangpur division use two part tariff as their major payment system. The farmers of Chittagong and Khulna divisions use fixed charge as their major payment systems for irrigation. Our survey shows, crop share payment is absent in Rangpur Division but in practical situation there is also some practice of crop share payment system for irrigation (Fig. 1).

Table 1. Division-wise major inputs use under different payment system for producing HYV boro rice (Figure per hectare)

Division name	Irrigation (Hrs)*				Labour (Man-day)			
	Own payment	Crop share	Fixed charge	Two part tariff	Own payment	Crop share	Fixed charge	Two part tariff
Chittagong	365	99	276	325	101	128	157	149
Dhaka	373	372	289	325	107	122	111	103
Khulna	561	480	430	451	131	128	130	124
Rajshahi	313	323	171	217	104	98	101	93
Rangpur	393	0	293	373	106	0	107	113
All	409	354	294	363	111	109	115	112

*Significant at 1 percent level of significance, Source: IRRI-BAU field survey, 2013

Our main interest in this study is to see the use of irrigation and labour per hectare under different payment system. Own payment is included here to get the comparison of inputs use among the payment systems. Irrigation hours use per hectare in fixed charge payment system is the lowest but labour use per hectare is the lowest in crop share payment system. Low labour use reminds us the old phenomenon of Marshallian views on share cropping in land rental markets. Irrigation hours use under different payment systems are significantly different at 1 percent level of significance. Differences of irrigation hours use are also significant among the divisions. We did not have significant differences of labour use per hectare among the payment systems but significant differences are found among the division levels at 10 percent level of significance.

Another important issue is to see that the hours of irrigation use is the highest in own payment system which indicates that the tubewell owners have more control of irrigation use than any other who does not have tubewell. On the other hand, labour use is lower in own payment system but its use is the lowest in crop share system.

Table 2. Division-wise inputs and labour cost under different payment system for producing HYV boro rice (Figure per hectare)

Division name	Total input cost (Tk.)				Total labourcost (Tk.)			
	Own payment	Crop share	Fixed charge	Two part tariff	Own payment	Crop share	Fixed charge	Two part tariff
Chittagong	13241	21300	25672	18047	37032	75747	57944	56598
Dhaka	15230	15408	14737	15518	51846	50591	58375	53444
Khulna	16375	17926	16545	16017	48087	48002	43673	35864
Rajshahi	13203	13663	13803	15025	44611	38900	37215	37303
Rangpur	15594	-	14942	14070	41347	-	42802	39528
All	15123	14735	15741	15216	46875	44243	44987	45084

Source: *IRRI-BAU field survey, 2013*

Table 2 shows that input cost other than labour is lower in crop share system but the differences are not significant among the payment systems and it is the same among all divisions. The same patterns are found in the case of labour use per hectare under different payment systems and divisions. The cost of labour use is also lower in crop share payment since its use is the lowest among all the payment systems.

Table 3. Division-wise service (irrigation and tillage) and other cost under different payment system for producing HYV boro rice (Figure per hectare)

Division name	Service cost* (Tk.)				Other cost (Tk.)			
	Own payment	Crop share	Fixed charge	Two part tariff	Own payment	Crop share	Fixed charge	Two part tariff
Chittagong	26083	23671	22533	20256	3850	0	1245	1740
Dhaka	24882	29147	20324	27958	1944	725	558	2020
Khulna	27678	29368	28985	31184	4312	286	1026	2322
Rajshahi	25239	28674	21740	18759	1752	986	680	4480
Rangpur	18625	-	18338	24968	1519	-	686	2055
All	24259	28875	22570	26963	2408	821	790	2137

*Significant at 1 percent level of significance, Source: IRRI-BAU field survey, 2013

Service cost includes the irrigation and tillage costs. The service cost per hectare is somewhat higher in crop share system and significantly different from other payment systems and divisions (Table 3). Tillage and irrigation cost vary due to the location factors. Irrigation cost in crop share system is calculated considering the share of harvested crop paid by the user to the seller. It makes the service cost higher in crop share system. Higher irrigation cost is the main consideration when the societies and the researchers found crop share payment inefficient.

Table 4. Division-wise yield and by-product of HYV rice under different payment systems (Figure per hectare)

Division name	Yield (Kg)*				By-product (Tk.)			
	Own payment	Crop share	Fixed charge	Two part tariff	Own payment	Crop share	Fixed charge	Two part tariff
Chittagong	4496	4611	5204	5657	2573	16467	4025	1019
Dhaka	6325	5832	6207	5990	4546	6334	4292	6550
Khulna	6706	6737	6326	6396	9819	7228	9337	7372
Rajshahi	6474	6283	6554	6652	5524	7597	6489	2071
Rangpur	6701	-	6502	6372	2244	-	2316	2096
All	6480	6147	6337	6199	5407	7163	5653	4812

*Significant at 10 percent level of significance, Source: IRRI-BAU field survey, 2013

It can be seen from Table 4 that the land productivity (yield) is the lowest in crop share system and this yield is significantly lower in crop share system compared to any other payment system. The important point here is that the yield is the highest in owner payment system. Due to that we need to investigate more about the economics of owning a tubewell in consideration of productivity, irrigation hours use, etc. Regular supply of water to the rice field is very important to produce HYV rice and this might be the reason behind more yield in own payment system.

Table 5. Division-wise cost and return of HYV rice under different payment systems (Fig. per hectare)

Division name	Total cost* (Tk.)				Total return (Tk.)			
	Own payment	Crop share	Fixed charge	Two part tariff	Own payment	Crop share	Fixed charge	Two part tariff
Chittagong	73654	96017	94415	85578	71148	91390	82074	87362
Dhaka	82737	89255	79993	85227	93600	92289	92043	96532

Khulna	84124	86348	78974	82510	108478	107775	106467	102607
Rajshahi	74821	76373	67154	68921	96568	97034	102822	72338
Rangpur	63497	-	64076	70868	87663	-	85406	80911
All	77049	82112	73246	79386	95775	96224	96261	91291

*Significant at 1 percent level of significance, Source: IRRI-BAU field survey, 2013

Table 5 shows that the total cost is higher in crop share system than any other systems and the cost is significantly different from other systems. On the other hand, returns are almost similar with own and fixed charge system but slightly different with two part tariff payment system. Test says the differences are not significant. So, it means that in crop share system the farmers are incurring more cost but not getting more returns We need to know more in depth explanations to accept a conclusion like that.

Investigation of inefficiency issue in different payment systems

Table 6. Likelihood percent of refusing irrigation water and users' plot visit by the seller in different payment systems (Fig. per season)

Division name	Likelihood percent of refusing irrigation water*			Users' plot visit by the seller (No.)		
	Crop share	Fixed charge	Two part tariff	Crop share	Fixed charge	Two part tariff
Chittagong	0	11.9	2.3	12	35	33
Dhaka	4.2	6.7	5.0	57	46	36
Khulna	4.7	5.9	3.2	66	48	44
Rajshahi	7.4	5.9	2.8	43	46	49
Rangpur	-	8.7	2.7	-	49	46
All	6.0	7.1	3.7	50	46	41

*Significant at 1 percent level of significance, Source: IRRI-BAU field survey, 2013

Data on two different variables likelihood percent of refusing irrigation water and user's plot visit by the seller, are shows in Table 6 to explain the inefficiency of crop share and other payment systems On an average, likelihood percent of refusing irrigation water is higher in fixed charge system but if we change the magnitudes of refusing, we can see the root causes are here in the likelihood of refusing irrigation water for its allocative inefficiency. Similarly, on an average condition,

the seller's visit to user's plot is higher but not significantly different from other systems. Another thing is that the seller's visits are higher in crop share system but the likelihood percent of refusing is not so lower like that. It is also an issue for having inefficiency in crop share payment system.

Table 7. Times of talk between buyer and seller regarding irrigation per season in different payment systems (Fig. per season)

Division name	Talking times between buyer and seller (No. per season: max=90)		
	Crop share	Fixed charge	Two part tariff
Chittagong	1	13	10
Dhaka	20	33	30
Khulna	23	25	33
Rajshahi	33	26	16
Rangpur	-	33	33
All	27	28	30

Source: IRRI-BAU field survey, 2013

Usual number of talk between user and seller is lower in crop share system and it is the highest in two part tariff system (Table 7). This interaction has strong value in irrigation water markets particularly to have irrigation water timely and sufficiently in the rice field during the HYV rice production season.

Sensitivity analysis:
Supervision issue in payment system in irrigation water market

In irrigation water market supervision of water to the user's plot is an important issue. The seller needs to visit user's plot time to time to check the water requirement of a plot. It is assumed that the more visit by the seller to user's plot may have chance to use more water which is the ultimate input for getting higher yield. In normal case, the seller visits user's plot 45 times in a crop season. On that level of visit, one farmer usually uses 301 hours irrigation and 110 man-days labour along with other inputs on per hectare basis. The average yield of the farmers is 6187 kg per hectare (Table 8)

Table 8. Situation of major driving variables with average visit by the seller to the user's plot (45) in different payment systems (Fig. per season)

Payment types	Target variables				
	Talk (No.)	Likelihood percent of refusing (%)	Irrigation (Hrs/ha)	Labour (Man-day/ha)	Yield (Kg/ha)
Crop share	22.0	7.1	328	102	6212
Fixed charge	21.9	7.4	275	113	6155
Two part tariff	23.6	4.4	319	112	6214
All	22.5	6.3	301	110	6187

Source: IRRI-BAU field survey, 2013

The irrigation and labour use depend on the number of visit by the seller to user's plot. It is seen from table 9 that the times of talking between user and seller is lower in fixed charge payment system compared to other payment systems. The farmers under fixed charge system use lower irrigation hours per hectare. Number of visit by the seller to user's plot is lower in two part tariff system since users are supposed to take more care of their own plots' irrigation. It was assumed that if commitment to provide water to users' plot somehow breaks, the hours of irrigation and labour use will be lower and it will affect the yield of HYV boro rice. If the likelihood of refusing irrigation percent would increase from 6 to 12%, the hours of irrigation and labour use per hectare would decrease 31.1 and 4.5 percent, respectively, which would ultimately affect yield. The more likelihood percent of refusing affects the use of irrigation hours more in crop share payment system than any other payment systems. Magnitude of the refusing percent is even more if it is reduced from 6 to 18%. In this situation, the hours of irrigation use per hectare would be 62.6 percent lower compared to the average level of use in crop share system. The important point here is to observe that the labour use per hectare (0.2%) would not decline like irrigation hours. It may reduce the yield (2.3%) as well like the previous situation. It makes significant difference between land markets and irrigation water markets.

Commitment issue in payment system in irrigation water market:

Table 9. Situation of major driving variables with average likelihood of refusing irrigation (6%) in different payment systems (Figure per season)

Payment types	Target variables				
	Talk (No.)	Visit (No.)	Irrigation (Hrs/ha)	Labour (Man-day/ha)	Yield (Kg/ha)
Crop share	24.2	54.2	401	111	6185
Fixed charge	23.6	45.9	324	118	6327
Two part tariff	29.2	43.2	372	113	6147
All	25.8	46.5	357	115	6232

Source: IRRI-BAU field survey, 2013

Transaction cost: Times of talk between user and seller in irrigation water market

To compare irrigation water market along with the land markets, let us check talking times between users and sellers and this impact on irrigation hours and labour use. First of all, we can look at the normal scenario of irrigation and labour use in table 9 where user-buyer talk 27 times during the whole irrigation season. On that context, they use 317 hours irrigation and 114 man-days of labour per hectare which gives on an average of yield, 6272 kg per hectare (Table 10).

Table 10. Situation of driving variables with average number of talk times (27) in different payment systems (Figure per season)

Payment types	Target variables				
	Likelihood of refusing (No.)	Visit (No.)	Irrigation (Hrs/ha)	Labour (Man-day/ha)	Yield (Kg/ha)
Crop share	5.2	45.4	354	110	6246
Fixed charge	6.5	41.9	284	117	6327
Two part tariff	3.5	34.7	341	114	6210
All	5.3	40.3	317	114	6272

Source: IRRI-BAU field survey, 2013

If the user-seller talks more regarding the irrigation water use in their plot, it shows that this transaction cost (talk between user and seller) from user side would increase the number of supervision of user's plot by the seller. It also reduces the likelihood percent of refusing irrigation to the user's (0.4%) plot. The conversation also helps to increase (1.6%) the use of irrigation hours per hectare. It has also been tested that those who have less number of talk between two groups (27 to 14%), they use less hours of irrigation and labour per hectare compared to the average situation. No significant differences were found among the payment system for irrigation.

This irrigation water market study is quite similar with land tenancy markets study done by Otsuka in the sense that in the land tenancy market study the author mentioned the transaction cost of land owner for the tenant in share cropping system. He proposed it for improving input use like seed, labour, fertilizer, etc. He emphasized this transaction cost for making more cash flow available to the tenant so that s/he can use it for input purchase. Supervision of tenant's activities like harvested amount and its distribution to the land owner was also the issue of land tenancy markets. Here we have considered that transaction cost for the cases of irrigation

hours use and also labour for explaining the irrigation water markets in relation to the different payment systems for irrigation in the HYV rice production. It has strong policy implications in a sense that without incurring any direct cost for getting more water, a farmer can push seller to provide more water in their plot which will ultimately produce higher yield. As a payment system, crop share was assumed to be the most inefficient one but the survey results say that the fixed charge system is also somehow inefficient in the sense of resource allocation. Two part tariff is better compared to the two other available two payment systems but it is not also out of those shortcomings. The farmers who are practising two part tariff have to face the problem of cash capital since they need regular fuel and service cost for using tubewell and providing water to the plot.

Times of talk issue in the case of land tenancy market:

Table 11. Situation of driving variables with average number of talk times (27) in different payment systems regarding land tenure status (Figure per season)

Payment types	Share cropping tenancy					Fixed renting tenancy				
	Likelihood of refusing (%)	Visit (No.)	Irrigation (Hrs/ha)	Labour (Man-day/ha)	Yield (Kg/ha)	Likelihood of refusing (%)	Visit (No.)	Irrigation (Hrs/ha)	Labour (Man-day/ha)	Yield (Kg/ha)
Crop share	8.8	51.5	302	104	5543	4.3	39.5	257	90	6693
Fixed charge	6.5	32.8	227	110	5997	6.0	36.9	273	124	6418
Two part tariff	2.7	25.3	358	111	6862	2.9	40.9	282	119	5718
All	5.4	32.5	285	110	6254	4.6	38.7	273	116	6231

Source: IRRI-BAU field survey, 2013

In the case of land tenancy markets, the major variable uses have the same directions and patterns as before. Irrigation hours use is little bit higher in share cropping. Its use is in fixed charge payment is lower than crop share payment. The most important point to see here is that the likelihood percent of refusing irrigation in share cropping tenancy is 8.8 in crop share payment which is much higher than fixed renting tenancy system and it indicates the very high rate of refusal there. The overall likelihood percent of refusing irrigation and labour use is lower in share cropping tenancy markets. Within the payment systems, the labour use is lower in crop share system which again reminds us the problem of share cropping system. We need to mention here one important thing that is the data is not sufficient enough to compare all this issues with irrigation water markets for comparing it with land tenancy markets. It is seen from the analysis that the times talk between user and seller in land tenancy markets has effect on resource use by the

tenants. If the user and seller have less scope to talk each other, there will be slightly lower use of inputs and these will produce lower yield of HYV boro rice production. The important message from this analysis is that irrigation hours use and labour use are not similar among the payments and we need to take that into consideration. We can push time of talk between user and seller but the improvement also depends on the payments types. It is not only a problem for crop share but it is also a problem for fixed charge payment system which was somewhat out of the researchers' consideration before.

Results from the specific models estimation:

We need to check the findings with the empirical model and how the specific target variables have influences there (Table 12). We have specified our model equation earlier. The results are as follows.

Model I: Major inputs included

Let us see the overall influence of the independent variables and dummies on the dependent variable, yield. Here we have keen interest to see the use of irrigation hours and labour use. This model I estimates the yield, 6292 kg per hectare in own payment system where soil type is loam and land type is low land. The coefficients of irrigation hours and labour are 0.37 and 0.30 respectively which mean an additional hour of irrigation may increase yield by 0.37 kg and an additional man-day of labour use may increase the yield by 0.30 kg. The coefficient of irrigation is significant at 5 percent level of significance. The coefficients of share pay and two part tariff payment dummies are negative 207.66 and 160.72, respectively, meaning that those who are in crop share and fixed charge payment systems may get 207.66 and 160.72 kg lower yield per hectare than the yield (62912 kg) of own payment system. On the other hand, the coefficient of fixed charge payment system (12.96 kg) means that the farmers using fixed charge payment have 12.96 kg more yield per hectare than own payment system. Other significant coefficients are farm size, kinship between user and seller and respondent's education. One hectare increase in respondent's farm size may increase yield by 246.24 kg and one year schooling education may increase yield by 30.20 kg.

Model II: Supervision included

In irrigation water market, supervision from tubewell owner to the user's plot is very important. In land tenancy markets, it was shown that the land owner's supervision has positive yield response of the share cropping tenancy system. It can also be seen from here that supervision by the seller has increased the labour coefficient from 0.29 in Model I to 0.88 though it is not statistically significant. Interaction coefficient of supervision with share cropping payment system shows negative 1.63. The interaction coefficient of fixed charge payment is 4.76 and statistically

significant (at 5 percent level of significance) and the meaning is that the supervision of seller to user's plot irrigation may increase yield by 4.76 kg per hectare. Negative sign of coefficient of supervision interaction factor indicates a lesses importance of supervision in case of crop share payment system. Again, farm size, kinship and respondent's education have statistically significant influence on yield of HYV boro production.

Model III: Commitment of seller included

Like land tenancy market, we have assumed here that the transaction cost between user and seller may increase yield in share crop payment system. As assumed and discussed in the hypothesis formulation part of this study, the transaction cost from user may not increase the yield in share crop payment system. We get the same indication here in Model III's output. Here it is seen that like Model II, the coefficient of labour increases (0.88 to 0.97) with the increase in times talk between user and seller but the value of irrigation coefficient again decreases (0.21 to 0.19). Here coefficients of times talk interaction with share and fixed payment systems are negative. Meaning is that the times talk between user and seller may not increase yield. It is seen that interaction factor of times talk with two part tariff dummy is positive but not statistically significant. Here sandy loam soil dummy, farm size, kinship dummy and respondent's education coefficients are positive and statistically significant.

Model IV: Transaction cost included in land tenancy markets

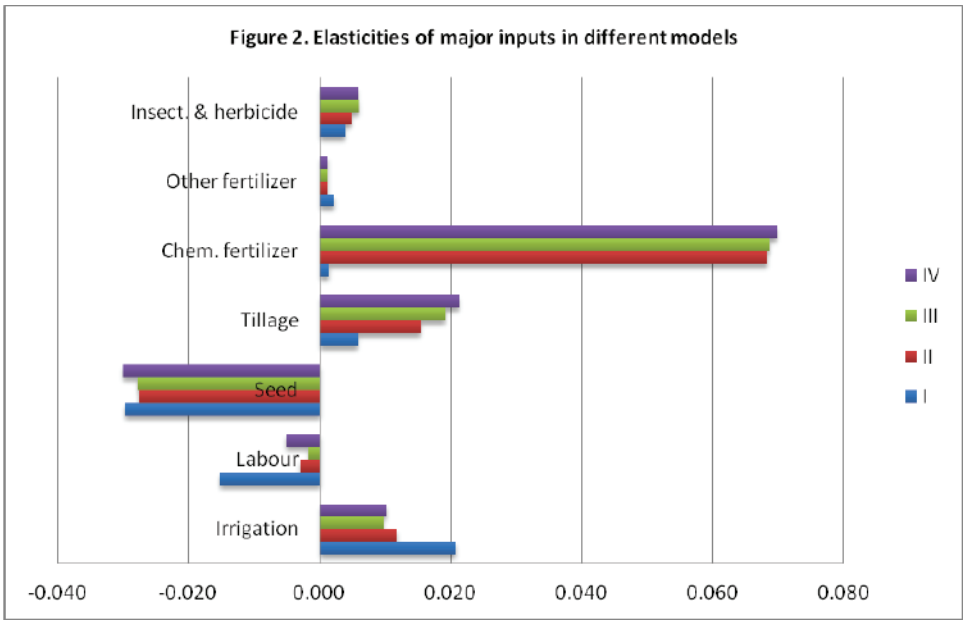
As discussed before, we have included transaction cost along with land tenancy issue here in this irrigation water market Model IV. The results of this model show that times talk interactions factors increase (0.22 to 0.23) the coefficient of irrigation hours in two part tariff payment system. It has reduced the coefficient of labour use from 1.03 to 0.95. Here yield increases from 5749 to 5762 kg per hectare. The coefficient of sandy loam dummy, farm size, kinship of user and seller and respondent's education have significant and positive influences on yield of HYV boro rice production.

Table 12. Summary of the variables and coefficients in different models

Name of variables	Values of the coefficients in different models			
	I	II	III	IV
Irrigation (hour)	0.34**	0.20	0.17	0.17
Labour (Man-day)	-0.75	-0.14	-0.08	-0.24
Seed (kg)	-5.08**	-4.78*	-4.79*	-5.20*
Tillage (hour)	3.41	8.75	10.87	12.09
Fertilizer (kg)	0.85***	0.77**	0.77**	0.78**
Other fertilizer (kg)	0.02	0.03	0.03	0.03
Insecticide & herbicides (kg/lit)	4.27	5.37	6.68	6.57
Share payment dummy	-215.21	70.72	129.04	212.10
Fixed charge dummy	-9.55	-84.37	-34.57	11.78
Two part tariff dummy	-162.81			
Share payment dummy* No. of visit		4.52**	4.49**	4.90**
Fixed charge dummy* No. of visit		-2.49	-2.71	-1.99
Share payment dummy*Likelihood percent of refusing irrigation			-7.31	-6.58
Fixed charge dummy* Likelihood percent of refusing irrigation			-8.25	-5.31
Share cropping dummy*No. of talk between user and seller				-2.40
Fixed renting dummy* No. of talk between user and seller				-4.87
Sandy loam soil dummy	-283.89**	-275.75**	-267.48**	-251.66*
Clay loam soil dummy	-68.70	76.76	97.42	94.76
Clay soil dummy	34.49	158.11	153.42	168.99
Medium high land dummy	-148.04	60.78	58.54	58.05
High land dummy	31.77	226.10	239.68	252.06
Farm size (ha)	231.71*	522.36**	536.13**	561.43**
Household head education (years schooling)	30.20***	32.99**	33.57**	33.06**
Kinship dummy	191.32*	230.82*	233.44*	236.68**
Irrigation distance (meter)	-0.13	-0.18	-0.17	-0.18
Constant term	5935.73	5427.50	5390.53	5383.78
No. of observation	958	716	716	716
Probability of F value	0.0000	0.0001	0.0002	0.0002
R^2	0.0570	0.0713	0.0736	0.0771
Adjusted R^2	0.0379	0.0445	0.0442	0.0450

*, **, *** indicate the significant at 10%, 5% and 1% significance levels

Elasticity of the major inputs:



The above elasticity of major inputs shows that there is a possibility to increase yield by increasing chemical fertilizer, tillage and irrigation hours.

Conclusions:

This paper presents information on the setant by variation in yield, irrigation hours use and labour use, under different payment systems and land tenancy situations. It also indicates the difficulties of supervision, commitment and transaction cost on the use of irrigation and labour uses. The tabular presentation and model analyses show that the variations of yield, irrigation and labour uses are different depending on the payment systems and land tenancy categories. Some cases of variation have been statisfication significant. Models show the same indications regarding supervision and commitment issues of providing irrigation water to the users' plot both in crop share payment and share cropping system. Among all the payment systems, crop share and fixed charge payments have resource allocation problems of irrigation water and labour uses and it may be also true for the other inputs use. This problem can't be improved so much like in the land tenancy market by the users through providing only transaction cost because they have no strong instruments. In the land tenancy market, landlords are the owner of very scarce resource, land, and the tenants are very obedient to the landlords otherwise they might lose it for future use. Landlords are also socially very dominant. In irrigation water market, these issues are almost absent and those make it different from land tenancy market. It is seen from the tabular analysis that the fixed charge system is less

viable since there is more scope to refuse irrigation water at times of scarcity of water, high price of diesel, bad relation between user and seller and limited cash flow to sellers in the pick time of rice growing since at that time crop needs water more frequently. The two part tariff has fewer demerits than both crop share and fixed charge payment systems since the user uses own diesel and labour for managing water by using tubewell. But this is limited scope of getting access to the tubewell in two part tariff system because other users are on queue for using tubewell.

References:

Cheung, S.N.S. 1969. *The Theory of Share Tenancy*, Chicago: University of Chicago Press.

Hayami, Y. and K. Otsuka 1993. *The Economics of Contract Choice: An Agrarian Perspective*, Oxford: Clarendon Press.

Johnson, D.G. 1950. Resource allocation under share contracts, Journal of Political Economy 58: 111–123.

Otsuka, K. and Hayami, Y. 1988. Theories of Share Tenancy: A Critical Survey. Economic Development and Cultural Change 57:31-68.