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Changes of Groundwater Markets in Bangladesh and West Bengal

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Introduction

Since its inception in the 1980s until now, groundwater irrigation by private shallow tube wells (hereinafter referred to as STWs) continued to play a vital role in the progress of rice-based agriculture and, as a result, the development of the rural economy as a whole in the lower Gangetic basin of Indian subcontinent. The Bengal, consisting of West Bengal, India and Bangladesh, once described as a case of 'agricultural impasse' by J.K. Boyce based on an analysis of his originally revised statistics until the end of the 1970s (Boyce 1986), were not exceptions for this wave of new technology induced rapid rural change since the 1980s. Accordingly, groundwater markets, involving tube well owners and non-owner farmers emerged at the village level, which had received great attention among researchers concerning their implications to efficiency and to rural income distribution.[1]

The purpose of this paper is to examine such efficiency and equity issues of groundwater markets, based on primary data collected in several selected villages in Bangladesh and West Bengal during the last decade. Special emphasis will be given to the changes of the market between the beginning (reported earlier in Fujita and Hossain 1996) and the end of the 1990s at the study villages in the north-western part of Bangladesh. In addition, results of the survey in a West Bengal village will also be presented for further discussions.

The composition of this paper is as follows. In Section 2, results of a study on the groundwater market in the study village in Bangladesh conducted by the author in 1992 will be briefly presented. In section 3, results of the re-survey in 1999 of the same area will be presented and the changes between the two periods and their implications will be discussed. In Section 4, the major findings from a study of a West Bengal village in 2000 will be discussed, especially in comparison with the Bangladesh case. In Section 5, socio-economic evaluation on groundwater markets in terms of efficiency and equity from the experiences of Bengal area will be summarized.

Groundwater Markets in a Bangladesh Village in 1992

The study village (hereinafter referred to as Village A) is located on a diluvial plateau locally called Barind tract in northwest Bangladesh, Bogra, and is free from regular floods (Map

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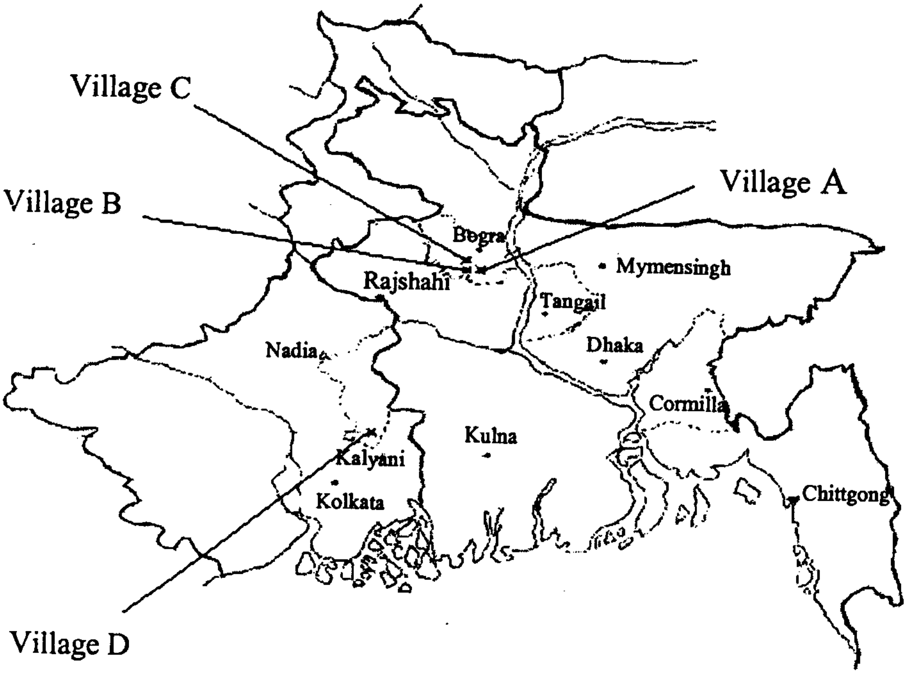
[1] See, for example, Bangladesh Agricultural University 1985; 1986; Wood and Palmer-Jones 1991, Pant 1992, Kahnert and Levive 1993, Shah 1993, Shah and Ballabh 1997.



Map 52.1: Bengal and the Study Villages

52.1). It had 209 households and 176 hectares of land at the time of the first survey in 1992. The Barind tract has long been known as a single cropping area of *aman*, traditional major rainy season rice, but the recent development of irrigation totally changed the situation. Namely, the rapid dissemination of private diesel STWs in the village during the 1980s drastically changed its cropping pattern, from single cropping of *aman* to double cropping of *aman*, followed by dry-season irrigated *boro* rice, in which high-yielding varieties (HYVs) started to be introduced.

Table 52.1 shows the process of STW diffusion in the village and more than 90 per cent of land had already been under irrigation in 1992. Table 52.2 shows how land distribution is skewed among the village households. Nearly half of the households are pure landless and 67 per cent of them rely mainly on agricultural hired labour, where off-farm job opportunities are extremely limited. On the other hand, the thirty-four (34) largest landowners occupy nearly 80 per cent of farm land, and it is these large farmers that possess most (22 out of 30) of the STWs in the village.

Table 52.1: Number of STWs in Village A, Bangladesh

Year	No. Installed	No. Accumulated
1981	1	1
1982	0	1
1983	0	1
1984	3	4
1985	1	5
1986	0	5
1987	2	7
1988	3	10
1989	7	17
1990	6	23
1991	5	28
1992	2	30

Table 52.2: Agrarian Structure of Village A, Bangladesh in 1992

Land Ownership Strara (Acres)	No. of HHs	Major Occupation of HH Head					Owned Land (Acres)	Operated Land (Acres)	No. of STWs
		Farming	Daily labour	Business	Service	Others			
0	102	18	68	6	1	9	0	28.6	0
0.01-0.49	34	15	9	4	0	6	7.2	16.7	2
0.50-0.99	14	8	4	0	0	2	9.7	21.4	2
1.00-2.49	25	18	1	1	2	3	34.2	40.5	4
2.50-4.99	17	13	0	0	3	1	56.8	62.2	8
5.00-	17	14	0	0	2	1	123.1	119.0	14
Total	209	86	82	11	8	22	231.0	288.4	30

Mode of Water Transactions

Table 52.3 listed all the STWs with such information as type and horse powers of diesel engine used for STW, whether it is new or second-hand, irrigated acreage under various contractual arrangements and so on. The irrigated area per STW varies from 5.4 to 20.0 acres, with the average of 10.3 acres. In the dry season, *boro* rice is basically planted with very minor exceptions where some kind of vegetables is grown.

Table 52.3: Contractual Arrangements in the Groundwater Market in Village A, Bangladesh in 1992

Serial No.	Type of engine	HP	New/Old	Irrigated Area (acres)					
				Total	Owned/ Exchanged	Chaunia	Water Sales Cash	Crop sharing	Mixed
1	Yanmar#	6	New	10.0	2.3	7.0			0.7
2	Yanmar#	6	New	18.0	1.3	9.7		7.0	
3	*	6	Old	9.3	5.0	2.3		2.0	
4	Mitsubishi#	6	New	9.6	2.0	6.3	1.3		
5	Yanmar	6	Old	13.3	3.3	5.0		5.0	
6	Yanmar	6	Old	17.0	7.7	9.3			
7	Yanmar#	6	New	6.7	5.0				1.7
8	Yanmar	6	Old	10.9	4.3	4.3		2.3	
9	Mitsubishi#	6	New	12.0		11.3	0.7		
10	Yanmar#	6	New	10.0	4.7	3.3			2.0
11	Yanmar	6	Old	11.3	2.7	4.3			4.3
12	Mitsubishi#	6	New	5.7		2.0		3.7	
13	Mitsubishi	6	Old	8.7	3.9	4.8			
14	Donfing	8.5	Old	10.0	8.3			1.7	
15	Yanmar	6	New	11.4	7.7			3.7	
16	Miyanton	6	New	6.3	1.0	2.0			3.3
17	Miyanton	6	New	6.7	1.0	2.0	3.7		
18	Miyanton	6	New	12.3	9.0				3.3
19	Mitsubishi	6	Old	10.7	2.0	8.7			
20	Yanmar#	6	New	20.0	4.7	6.0		9.3	
21	Miyanton	6	New	12.7	4.7	6.3	0.7		1.0
22	Yanmar	6	Old	8.0	3.3	4.7			
23	Yanmar	6	Old	8.0	5.0			3.0	
24	Donfing	6	New	10.0		8.0		2.0	
25	*	6	Old	8.4	2.7	4.0	1.7		
26	Mitsubishi	6	Old	6.7	2.0			4.7	
27	Yanmar#	6	Old	11.7	4.3	6.7			0.7
28	Miyanton	6	New	9.0		7.0			2.0
29	Yanmar	6	Old	5.4	4.2				1.2
30	Yanmar	6	Old	7.8	4.3	2.7			0.8
Total				307.6	106.4	127.7	8.1	44.4	21.0
Average				10.3	3.5	4.3	0.3	1.5	0.7

Note: # means Japanese new engines.
* means unidentified types of engine.

The contractual arrangements can be classified into the following three broad categories. The first is the STW owners' owned and self-cultivated land. Temporarily exchanged land among STW owners, though very small, is also included in this category. In total, 35 per cent of total land is irrigated under this arrangement.

The second is the seasonal tenancy by STW owners. Under this system, locally called *Chaunia*, three (3) *maunds* (1 *maund* = 37.3 kg) of paddy per *bigha* (1 *bigha* = 1/3 acre) is paid as land rent to landowners, while the average yield of *boro* at that time was about thirteen (13) *maunds* per *bigha*. About 42 per cent of total irrigated land is under this arrangement and is the largest.

The third arrangement is the water sales, occupying 24 per cent of the total irrigated area. STW owners are responsible for the excavation of irrigation channels for water buyers every season. This system is further subdivided into three categories in terms of mode of payment of irrigation charge; i.e. 1) fixed cash payment system, 2) crop sharing system, and 3) mixed system of cash payment and crop sharing.

Under the fixed cash payment system, water buyers must pay in advance, ranging from 2,100 to 2,400 taka per acre. In case of crop sharing, the share accrues to STW owners is either 33 per cent or 40 per cent. Among the total eleven cases observed, six paid 33 per cent and the remaining five paid 40 per cent. If converted into monetary term, payments range from 3,000 to 3,500 taka per acre. Lastly, the mixed payment system means that a portion, usually 300 taka per acre, is paid in advance and the remainder is paid as a share of harvested paddy, which is usually 33 per cent.

Cost of Irrigation and the Water Charge

Table 52.4 summarizes the estimated cost of irrigation and the water charge for all the STWs. Cost of irrigation comprises of operation, maintenance (diesel & lubricant oil, spare parts & repair, and labour) and capital cost (depreciation of STWs). Labour is employed for such works as excavating channels, operating STWs, and as night-guards to prevent theft. The depreciation cost is estimated by the constant amount method, assuming a life of ten years for new Japanese engines and five years for the others. Water charge, on the other hand, is listed when water sales transaction is involved and if water charge is collected through crop sharing, it is converted in monetary terms. It should be noted here that since it is paid after harvesting, which is different from the case of the fixed cash payment system that is paid in advance, interest should have been added, but for the time being we did not.

The estimates of w/c (w = water charge, c = O&M cost) and w/ac (ac = total cost) for each STW are summarized in Table 52.4. The value of w/c, which is a good indicator of the 'monopolistic' degree of the said 'groundwater market'[2], ranges from 1.13 to a maximum of 6.18 with an average of 2.59. The STW No.25, whose value of w/ac registers below unity, is the only case of the financial deficit.

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[2] According to Shah (1993), the profit P that accrues to STW owners is defined as follows:
P = wA – cA – F, where A is the acreage of water sold (assuming that all the water is sold), w is the water charge per acre, c is the operation and maintenance cost (per acre), and F is the fixed capital cost during the irrigation season (depreciation cost of STWs). Now assuming the water seller holds a monopoly and his behaviour is to maximize profit, the equilibrium water charge w* is obtained as follows:
w* = e/(e-1)_c, where e represents the price elasticity of the demand for water.
Thus we get w/c = e/(e-1), which can be an indicator of 'monopolistic power' of STW owners in the groundwater market.

Table 52.4: Cost of Irrigation and Water Charge in Village A, Bangladesh, in 1992 (per acre)

Serial No.	Operation and maintenance cost				Depreciation cost	Total cost (ac)	Water charge (w)	w/c	w/ac
	Fuel and Lubricant oils	Spare parts and repairs	Wages	Sub-total (c)					
1	1,149	220	248	1,617	328	1,945	3,000	1.86	1.54
2	578	0	106	684	122	806	3,450	5.04	4.28
3	904	215	81	1,200	323	1,523	3,080	2.57	2.02
4	1,043	247	116	1,406	306	1,712	2,250	1.60	1.31
5	1,096	276	150	1,522	165	1,687	3,220	2.12	1.91
6	624	78	55	757	165	922			
7	1,209	200	313	1,722	224	1,946	3,900	2.26	2.00
8	1,032	259	145	1,436	273	1,709	3,312	2.31	1.94
9	989	565	131	1,685	125	1,810	2,400	1.42	1.33
10	950	252	225	1,427	280	1,707	3,450	2.42	2.02
11	714	33	0	747	345	1,092	4,620	6.18	4.23
12	1,119	142	118	1,379	807	2,186	3,240	2.35	1.48
13	622	78	54	754	276	1,030			
14	1,008	194	264	1,466	400	1,866	3,300	2.25	1.77
15	945	238	207	1,390	389	1,779	3,168	2.28	1.78
16	1,314	343	305	1,962	730	2,692	3,160	1.61	1.17
17	1,067	0	149	1,216	448	1,664	2,100	1.73	1.26
18	972	64	143	1,179	285	1,464	2,940	2.49	2.01
19	995	266	210	1,471	243	1,714			
20	776	225	67	1,068	140	1,208	3,864	3.62	3.20
21	1,115	180	150	1,445	250	1,695	2,720	1.88	1.60
22	929	264	115	1,308	414	1,722	2,100	1.61	1.22
23	810	533	220	1,563	550	2,113	3,450	2.21	1.63
24	950	0	160	1,110	360	1,470	3,456	3.11	2.35
25	1,528	325	0	1,853	361	2,214	2,100	1.13	0.95
26	779	190	0	969	418	1,387	3,680	3.80	2.65
27	855	145	192	1,192	410	1,602	3,900	3.27	2.43
28	1,096	143	0	1,239	411	1,650	2,740	2.21	1.66
29	1,531	306	283	2,120	679	2,799	3,660	1.73	1.31
30	1,297	277	0	1,574	487	2,061	3,500	2.22	1.70
Weighted average	920	191	128	1,240	366	1,606	3,210	2.59	2.00

Comparing the estimates of w/c in Village A with several other case, studies in Bangladesh shown in Table 52.5, in which w/c ranges, on average, from 1.16 to 2.53, it can be said that our case study marked a very high value of w/c. However, it seems too hasty to conclude that the groundwater market in our study village is highly monopolistic. Let us proceed to more in-depth analysis on the distribution of benefit, by defining and measuring net irrigation surplus.

Table 52.5: Results of the Other Major Studies of Groundwater Market in Bangladesh

Serial No. of cases	Characteristics	No. of samples	Average irrigated area (acres)	Payment System (%)			Cost of fixed capital (taka)		Per acre (taka)		w/c
				Fixed cash	Crop share	Others		O&M (c)		Water charge (w)	
1	STW		41	11.2	49	17	34	22,000	515	1,264	2.45
2	LLP		61	37.8	82		18	31,250	390	667	1.71
3	DTW		36	62							
	Electricity	29	64	100			130,000	407	839	2.06	
	Diesel		7	54		100		130,000	807	1,680	2.08
4	DTW		18	49							
	Fixed cash	5	59	100			130,000	681	793	1.16	
	Crop sharing	13	45		100		130,000	861	2,122	2.46	
	STW		37	11.6		100		30,000	1,025	2,380	2.32
	LLP		5	20.3		100		21,160	831	2,099	2.53
5	DTW		26								
	Fuel born by TW owners		63.3	100			130,000	795	980	1.23	
	Fuel born by farmers		45.6	100			130,000	288	459	1.59	
	LLP		17	32.4	82		18	28,750	433	728	1.68

Source: 1: Hamid, M.A. et al., (1982). *Shallow Tube wells under IDA Credit in North Bangladesh*, Rajshahi University.

2: Ibid., (1984). *Low Lift Pumps under IDA Credit in South East Bangladesh*, Rajshahi University.

3: Jaim, W.M.H. and P.K. Shikhadar, "Privatization of Deep Tube well- A Shift from Renral System: Who Gets Benefit?", mimeographed (n.d.).

4 & 5: Bangladesh Agricultural University, (1985). *Evaluating the Role of Institutions in Irrigation Programme.*

Distribution of Net Irrigation Surplus

Let us define net irrigation surplus (NIS) as the surplus in which all the necessary cost except for the cost of land rent and interest for working capital for irrigated rice production is deducted from the gross revenue. In theory, NIS is composed of land rent, interest on working capital, and profit (operators' surplus).

NIS can be estimated for every STWs, but here in Table 52.4 we show the aggregated NIS for all the STWs in the village and its distribution among landowners (who own land but rented it out to STW owners in the dry season), farmers (water buyers), and STW owners. It indicates that the total NIS produced during the 1991/92 irrigation season is approximately 1.3 million taka, and its distribution is as follows: 20 per cent to landowners, 15 per cent to farmers, and the remaining 64 per cent to STW owners.

Instead of individuals such as landowners, farmers, and STW owners, the distribution of NIS can also be looked at from the viewpoint of factors of production. Let us next proceed to this aspect.

First, all the surpluses going to landowners can be regarded as land rent, thus land rent (3 *maunds* of paddy per *bigha*) can be separated. Second, the surplus going to farmers can be decomposed into land rent, interest for working capital, and operators' surpluses (profit). Considering that the short-term interest rate in informal credit market in the study village is more or less 100 per cent per annum, and assuming a two-month borrowing period on average in the case of *boro* production, the amount of interest can be estimated and separated. Thus as Table 6 shows, operators' surpluses will be minimal (2,052 taka) in case of farmers, indicating that almost all the surpluses accrued to them can be explained by land rent and interest for working capital. Third, by the same token, the surplus going to STW owners can be decomposed into land rent, interest for working capital, and profit. It is evident from the table that a substantial part of the surplus STW owners obtained is nothing but a profit.

Figure 52.1 illustrates a summary of the factor share distribution for irrigated *boro* rice production. At the lower part of it, it is illustrated how NIS is distributed between STW owners and non-owners under different contractual arrangements. Namely, under the seasonal tenancy, *Chaunia*, non-owners can get only land rent, while if they purchase water and cultivate land by themselves they can get, in addition to land rent, interest for working capital for cultivation as well. In case of fixed cash payment system, they get larger interest income because they also bear the working capital for irrigation through in-advance payment of the water charge.

The critical issue is that whether the profit STW owners obtained has certain economic rationale or not. Figure 52.2 shows the distribution of annual rate of return to STW investment, in relation to the achieved irrigated acreage in 1992. It is found that the average of it is 69 per cent, although scattered very largely. In the study village, there is a long-term land tenancy system, locally called *khaikhalashi*, wherein an advance payment of 10,000-15,000 taka per acre makes it possible for the payer to secure cultivating right of land for seven

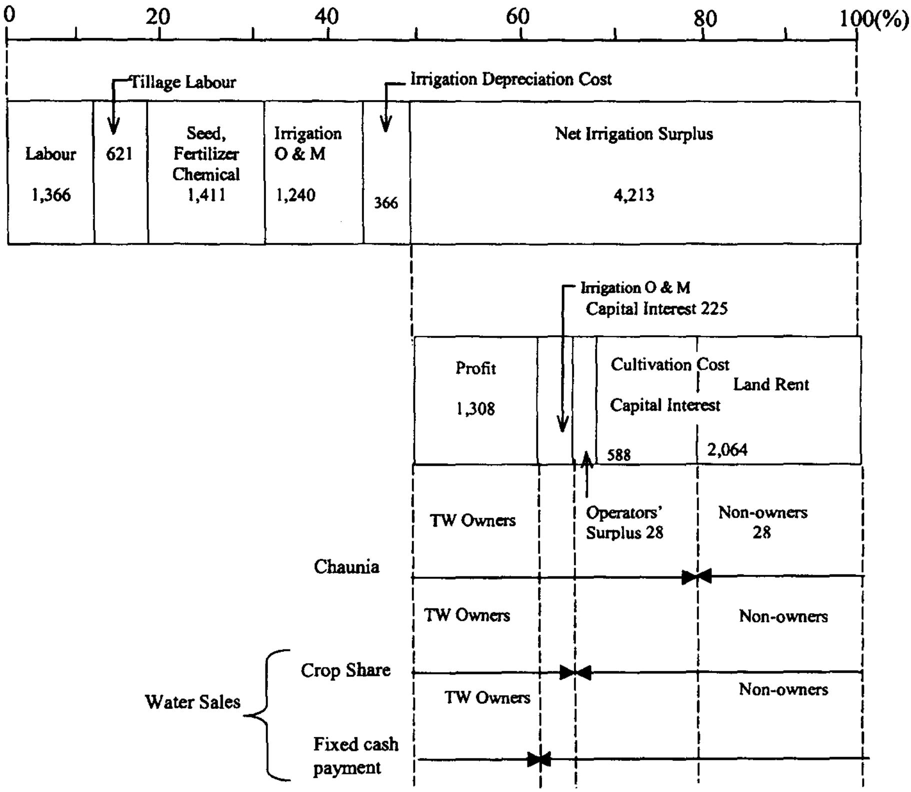

Figure 52.1: Bengal and the Study Villages

Table 52.6: Distribution of Net Irrigation Surplus in Village A, Bangladesh in 1992

	Land owners	Farmers	TW owners	Total	Per acre
Land rent	265,446	150,750	218,507	634,703	2,064
Interest on working capital					
for cultivation	0	41,772	139,064	180,836	588
for irrigation	0	3,927	65,238	69,165	225
Profit (Operators' surplus)	0	2,052	408,710	410,762	1,336
Total	265,446	198,501	831,519	1,295,466	4,213

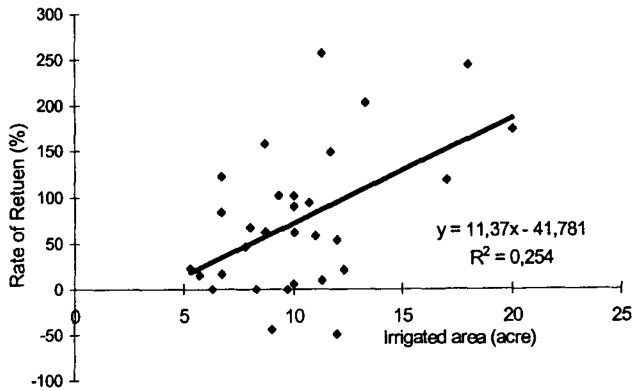

Figure 52.2: Rate of Returns to STW Investment in Village A, Bangladesh (1992)

Table 52.7: Changes of Groundwater Market in Two Villages in Bogra, Bangladesh

	Survey year	No. of STWs	Irrigation ratio (%)	Average irrigated area per STW (acres)	Yield of *boro* (*maunds*/ *bigha*)
Village A	1987-1999	38-80	94-100	12.0-6.1	10-11-12-15
Village B	1992-1999	30-52	90-100	10.3-6.6	13-16

years. Considering that the annual expected land rent per acre is about 6,354 taka, according to the estimates based on our production cost survey in the village, the rate of return to this investment to long-term tenancy will be approximately 50 per cent, ranging between 38 and 61 per cent. It can thus be concluded that the rate of return to STW investment is generally, but not 'extra-ordinarily', higher than the other major substitutable investment opportunity in Village A. It can be said that investment to STWs was not bad at least up to the beginning of the 1990s. However, the situation rapidly changed afterwards, which was revealed through the re-survey in 1999.

Transformation of Groundwater Markets during the 1990s

In 1999, seven years after the first survey, a re-survey on groundwater markets was conducted in the same village and also in the surrounding rural areas in Bogra, Bangladesh.

Table 52.7 shows how the situations on groundwater irrigation changed, taking two villages (including Village A) as examples. Another village, named B, is selected for the survey in 1999 because reliable data on groundwater markets were available for the year, 1987 (Ando, Rashid, and Kaida 1991). It is clear from the table that in both villages although irrigation

Table 52.8: Process of Diffusion of Tube Wells in Village C, Bangladesh

	Diesel STWs		Electricity STWs	DTWs
	New	Replacement		
1982	1			
1983	1			
1984	1			
1985	4			
1986		2		
1987	2			
1988		2		
1989	1			
1990	1	2		
1991			1	1
1992	1	1		1
1993	1	1		
1994	4	1	1	
1995	1	1		
1996		2		
1997	1	2		
1998	2	2		

had already covered more than 90 per cent at the end of the 1980s or at the beginning of the 90s, further introduction of STWs did not discontinue and their number had actually more or less doubled. As a result, the average per STW irrigated acreage reduced from 10-12 acres to 6-7 acres. It should be noted that in a newly selected village (hereinafter referred to as Village C) for an in-depth study, which is not far from Village A and B, the average irrigated acreage per STW is 6.1 acres as reported later, and it seems that the village also experienced the same movement of decreasing command area per STW, although the data for the past is not available.[3]

The details on what happened in groundwater markets in this area of Bangladesh, taking Village C as a case study is presented next.

Outline of the Study Village

The Village C is also located on Barind tract and is free from regular floods (Map 52.1). Unlike Village A and B, it is located along the highway connecting the two cities of Bogra and Rajshahi and so, blessed with good infrastructure. The village is partly electrified and

[3] The 'excess' investment in STWs in confined areas and the resulting decrease of command area in which many tube wells incur loss can be generalized in the whole country of Bangladesh, at least if we closely examined official irrigation-related statistics. See also International Irrigation Management Institute with the Bureau of Socio-Economic Research and Training of the Bangladesh Agricultural University 1996.

thus some tube wells are operated by electricity. It had 194 households and 201 hectares of land at the time of the survey by OECF[4] in 1996. In 1999 there are in total two (2) deep tube wells (hereinafter referred to as DTWs) and twenty-four (24) STWs in the village.[5] Both DTWs are electricity- operated, while most (22 out of 24) of the STWs are still diesel-operated. Large farm households owning more than 2.5 acres possess most of the tube wells in Village C, same as the other villages reported earlier.

Table 52.8 shows the process of tube well diffusion in the village where almost 100 per cent of land is under irrigation in 1999. It seems that by the time two DTWs were introduced in 1991 and 1992, the groundwater market of the village was already 'saturated'. No STWs were installed after that period. The major cropping pattern is *aman* followed by irrigated *boro*, but in about 15 per cent of total land, triple cropping of *aman*- potato/mustard- *boro* is practiced. Irrigation water is necessary for potato (and partly for mustard) besides *boro* rice in this case.

Changes in the Mode of Water Transactions

The total irrigated acreage by tube wells reached to 267 acres of *boro*, 37 acres of potato/ mustard, and 2 acres of the other crops in Village C in 1999. Various contractual arrangements are also observed in the village, which can be classified into three categories as 1) owned and/or temporarily exchanged (and self-cultivated) land of tube well owners, 2) rented-in and/or mortgaged-in land by tube well owners, 3) water sales. For the irrigation to *boro*, 17per cent (45 acres), 13 per cent (35 acres), and 70 per cent (187 acres) of land is classified into the first, second, and third category respectively. In case of potato/mustard, on the other hand, the same figures are respectively 43 per cent, 24 per cent, and 32 per cent.

It should be noted here that the second category mentioned above is different from the seasonal tenancy called *Chaunia* found in Village A, in which land rent is paid in kind. Tenancy in Village C can be divided into seasonal (locally called *potton*) and yearly (*sonpotton*), where both are paid in cash and in advance. It can be said that the tenancy system found in Village C should be regarded as a more 'modern' type compared to *Chaunia* system. Water sales transactions also seem to be 'modernized', there because only fixed cash payment system (two times instalment) and no cases of crop sharing are observed. However, the mortgage arrangement popular in Village C is *khaikhalashi*, the same system that was found in Village A.

It is found that the major contractual arrangement in Village D is water sales with cash payment, which is a sharp contrast with the case of Village A at the time of 1992. It should be added that in the 1999 survey in Village A, the *Chaunia* is no longer practiced and water sales transactions with fixed cash payment system became dominant.

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4 Overseas Economic Cooperation Fund, a governmental development financial institution in Japan, was reorganized and re-named as JBIC (Japanese Bank for International Cooperation). In 1996, for the evaluation of Grameen Bank housing loan project, it selected Village C as one of the research sites, in which the author also participated.

5 DTWs were sold to individual farmers by BADC (Bangladesh Agricultural Development Corporation) at a highly subsidized price, which is the major reason why they succeeded to operate DTWs without loss.

Changes in the Profitability of Tube Well Management

Table 52.9 summarizes the result of analysis on cost and return of tube well management, by classifying them into four categories of 1) deficit diesel STWs, 2) surplus diesel STWs, 3) electricity STWs, and 4) DTWs. Among the total twenty (20) diesel STWs, thirteen (65%) recorded financial deficit and the remaining seven (7) recorded surplus.

Figure 52.3 illustrates the distribution of annual profit for every tube well in relation to the achieved irrigated area. Comparison of this figure with Figure 52.2 (for Village A in 1992) makes it possible to point out several findings and hypotheses.

First, the profitability in tube well management seems to become more correlated with the achieved irrigated acreage and it is about 9 acres that separates those generating a profit from those incurring a loss.

Table 52.9: Cost and Return of Tube Well Management in Village C, Bangladesh in 1999

	Diesel STWs					Electricity	
	Deficit			Surplus		STWs	DTWs
No. of samples	13			7		2	2
Initial investment	14,027			14,757		23,750	214,000
Irrigated crop	Potato/ Mustard	Boro	Others	Potato/ Mustard	Boro	Boro	Boro
Total command area (acres)	23.1	65.4	2.0	14.2	56.8	29.0	115.5
Owned/Exchanged	9.9	22.6	0	6.4	14.1	5.7	3.0
Mortgaged-in	0.1	3.1	0	0	2.5	1.7	0
Rented-in	6.2	12.6	2.0	2.5	2.5	3.0	9.2
Water sales	6.9	27.1	0	5.3	37.7	18.6	103.3
Per TW acreage	1.78	5.03	0.15	2.03	8.11	14.5	57.8
Water price (taka/acre)	390	1,776	360	626	1,801	1,500	1,386
Per TW:							
Total gross revenue (A)	9,683			15,884		21,750	80,042
Gross revenue from each crop	693	8,935	55	1,270	14,614	21,750	80,042
Cost							
Diesel/Electricity	4,938			5,677		9,250	34,500
Lubricant oils	386			524		0	0
Spare parts/Repair	1,468			971		1,100	0
TW house	632			464		1,000	2,400
Hired labour	2,235			3143		5,625	12,000
Family labour (C)	2,792			1647		0	0
Interest on working capital	623			621		849	2,445
Depreciation	706			646		792	6,420
Total (B)	13,780			13,693		18,616	57,765
Net revenue (A)-(B)	(4,097)			2,191		3,134	22,277
Income (A)-(B)+(C)	(1,305)			3,838		3,134	22,277

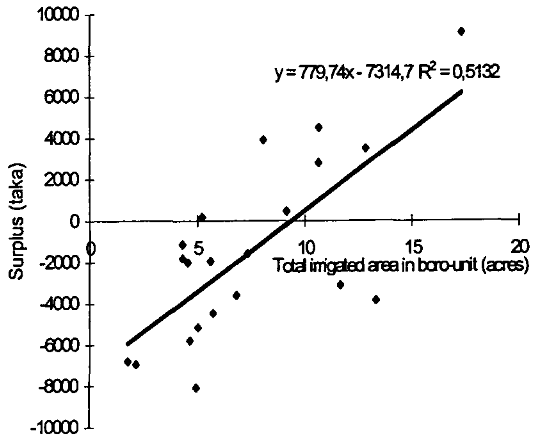


Figure 52.3: Profitability of Tube-well Investment in Village C, Bangladesh (1999)

Second, the fitting line seems to shift downwards, which means that in general the rate of return to tube well investment becomes much lower than before. The overall picture indicates that the rate of return to tube well investment is close to zero or even negative, which is a sharp contrast with the case of Village A in 1992, where it generated an average of 69 per cent of profit per year.

The reason for it is clear enough; i.e. the 'over-' investment in tube wells and the resulting decrease of command area as well as the decline of real water price. The implications of the decline of real water price are discussed next. The issue relating to why 'over-' investment took place will be examined later.

Implications to Income Distributions

Table 52.10 summarizes the result of cost and return analysis of major crop production in Village C. It should be noted here that the data is collected from tube well owners where the majority of them are large farmers and thus the data show some upper sample bias. But the fact that the operators' surpluses obtained from the estimates more or less coincide with the prevailing land rent in the village tenancy market[6] means that the estimates are reasonable and reliable.

[6] The prevailing land rent for *boro* season (*potton*) was 3,600-4,500 taka per acre, which is actually much lower than the operators' surplus of 6,353 taka generated from *boro* production, but if interest for working capital for cultivation is incorporated, the rate will be 4,320-5,400 taka per acre, still substantially lower than the surplus. However, according to interviews *potton* for *boro* season was disappearing rapidly due to such 'dis-equilibrium' and instead *sonpotton* (9,000-9,900 taka per acre) for a whole year were expanding. Careful calculations for *sonpotton* revealed that under this system the loss of land rent in *boro* season is almost fully compensated by the excess land rent in *aman* season.

Table 52.10: Cost and Return of Crop Productions in Village C, Bangladesh in 1999

	Boro		Aman		Potato		Mustard	
No. of samples	8		7		4		3	
Average cropped area (acres)	4.35		4.60		1.23		1.06	
Yield (ton/ha)	4.49		3.23		14.53		0.69	
Sales price (taka/maund)	250		269		121		633	
(Per acre)	Taka	Share (%)	Taka	Share (%)	Taka	Share (%)	Taka	Share (%)
Gross revenue	12,916	100	10,545	100	19,800	100	4,750	100
Paddy	12,147		9,366					
Straw	769		1,179					
Cost	6,564	51	4,454	42	13,958	70	3,743	79
Seed	288	2	183	2	3,855	19	168	4
Fertilizer	1,430	11	751	7	3,817	19	1,517	32
Chemicals	67	1	0	0	807	4	0	0
Irrigation	1,637	13	0	0	743	4	150	3
Machine rental	394	3	1,064	10	1,080	5	640	13
Hired labour	2,151	17	2,051	19	1,366	7	380	8
Family labour	0	0	0	0	1,781	9	710	15
Interest on working capital	597	5	405	4	509	3	178	4
Net revenue	6,352	49	6,091	58	5,842	30	1,007	21

First, it is found that the share to water in *boro* production is only 13 per cent (1,637 taka per acre). It was 31 per cent (1,606 taka of cost plus 1,336 taka of profit) in the case of Village A in 1992, much higher than Village C in 1999. It seems that the cost of irrigation did not change in nominal terms, and thus in real terms it experienced a decline if inflation is taken into account. In addition, a large amount of profit accrued to tube well owners before seems to disappear totally, thus contributing to a substantial decline of real water price faced by the water buyers.

Second, while the share to water decreased sharply, the share to land, once declined substantially, increased again to a very high level. Namely, while it was only 22 per cent before, it has increased to as much as 49 per cent.

Table 52.11 summarizes the changes of factor share in *boro* production and indicates that land absorbed the decreased share of all the other factors of production, especially the decreased share of water. Therefore, the benefit, from the increased competitiveness of groundwater markets during the 1990s is accrued to landowners and not to the owners of other factors including labour and capital.

Table 52.11: Changes of Factor Shares in *Boro* in Bangladesh

	Village A in 1992		Village C in 1999	
	taka/acre	Share (%)	taka/acre	Share (%)
Current inputs	1,411	15	1,785	14
Water charge	2,942	31	1,637	13
Cost	1,606	17		
Profit	1,336	14		
Labour	1,987	22	2,545	20
Ploughing	621	7	394	3
Others	1,366	15	2,151	17
Interest on working capital	813	9	597	5
Land rent (Operators' surplus)	2,064	22	6,353	49
Total	9,217	100	12,917	100

Can the Investment Behaviour Be Said as Really Irrational?

If it is very plausible that the investment to tube wells continued to go beyond the point where its rate of return is equal to that of the other investment opportunities in rural areas, then what was the cause behind such a phenomenon? In other words, can the behaviours of farmers to 'over-' invest in tube wells be regarded as economically irrational?

To answer this question, the analysis on cost and return of tube well management shown in Table 52.9 needs to be re-examined carefully. Several points will be raised and discussed.

First, there is a possibility that the labour cost is over-estimated in the sense that family labour cost is calculated based on answers of TW owners to the question how much is necessary, if hired. However, even under the assumption of zero family labour cost, the deficit diesel STWs cannot be escaped, on average, from the deficit itself and thus the over-estimated labour cost hypothesis is far from satisfactory to refute the 'irrational' behaviour of farmers.

Second, there is a possibility that if one has his own tube well, he can utilize his land more intensively compared to the situation when he had to purchase water from others. Here intensive land use means that he could accomplish triple cropping in a higher portion of his land, and/or he could get higher yield in *boro* or potato/mustard production in his own plots.

The plausible effect of raising cropping intensity is already incorporated in the calculation in Table 52.9, but if the fact that triple cropping became actually possible almost only when one possesses his own tube well is taken into account, the operators' surpluses generated from the additional cropping of potato/mustard should be added to the return to tube well irrigation. Considering the difference in cropping intensity of 24.9 per cent (231.4 per cent in case of tube well owners minus 206.5 per cent in case of non-owners), and given the fact that the average cropped area of *boro* by tube well owners is 2.95 acres, and considering

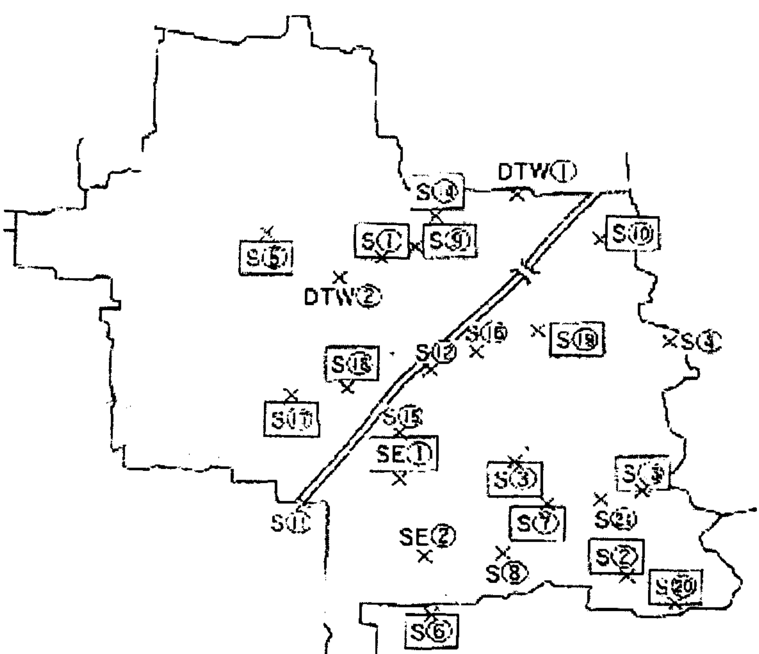
3,333 taka per acre of operators' surpluses for potato/mustard (weighted average), the additional income will be as much as about 2,500 taka.

Another possible effect is the yield of crops which is totally neglected in Table 52.9. According to the group discussion and based on other supplemental interviews carefully conducted in September 2000, it was revealed that the difference in *boro* yield arising from the ownership of tube wells could not exceed 2 per cent. But if 2 per cent difference is converted to monetary terms, the additional income will reach to more or less 800 taka.

Thus in Figure 52.3, every point should be shifted upwards by about 3,300 taka on average. In sum, if these possibilities were taken into account, the profitability of tube well investment would improve by a substantial degree, but still seem to be weak to completely refute the hypothesis of 'irrational' behaviour of farmers, based on direct interviews to TW owners and water buyers.

Why Trapped in 'Over' Investment in Tube Wells?

In order to investigate this issue further, the location of every tube well is drawn in the *mauza* (mauza means revenue village) map. Let us try to examine one by one the reasons why they fell into the financial deficit (Map 52.2).



Map 52.2: Location of Tube Wells in Village C

First, S1, S9, S10, S14, and S19 are the cases of new introduction of STWs in the command area of DTW1. Except for S9 that was installed in 1985, all other STWs were installed after 1991; i.e. in 1994 in case of S14 and S19, and in 1998 in case of S1 and S10. Because the owner of DTW1 was giving discount to the water charge by a substantial amount,[7] the new comers failed to secure enough command area, thus, they suffered from financial deficit.

Second, S18 installed in 1994, is located between the two earlier installers of DTW2 and S17 and thus failed to secure enough command area. It seems that S17 fell into deficit too due to the intrusion of S18.

Third, S2, S3, S7, and S13 are the cases of competition with S21. Except for the case of S13, all the STWs are installed later than S21and thus failed to secure enough command areas.

Fourth, the case of SE1 installed in 1994 deserves special attention. It seems that it failed to deprive enough command area from S15, although it offered 17 per cent lower water charge. S15 is the STW operated by a powerful *madrassa* (Islamic primary school) teacher, who started its operation in 1982, the first in the village.

Generally, many STWs that fell into financial deficit seems to be the cases of new 'intrusion' into the already well-established command area of earlier tube wells. In response to the author's question why they have installed their new tube well unreasonably, a typical answer was because tube well owners from whom they once purchased water did not supply water "properly", ie. "supplied water at their own will". A relating comment of the owner of DTW1 was "Hey, can you see the points of STWs within the command area of my DTW?" and continued, "Although I discounted water charge in a substantial degree, farmers who want to try to install their own STWs did appear. If not discounted, there would be more such farmers". It should be added that a typical comment by tube well owners to the complaint of the water buyers mentioned above was that the water buyers are inclined to refuse the payment of water charge whenever it is possible and it is sometimes really hard to collect it. "Under such circumstances, why should I supply water as they like?"

It should be noted here that these comments from both sides of water buyers and sellers are the 'extremes' and in the regular transactions of water they may actually be more cooperative and behave more friendlily.

However, at the same time it can be said that the so-called transaction cost in water sales is far from negligible in Bangladesh due to the tendency of behaviour of moral hazard in both parties. The existence of such high transaction costs is attributable to the difference in the intensity of land use between tube well owners and non-owners, which was discussed earlier. However, this kind of transaction cost cannot totally be evaluated in monetary terms, which

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7 While the water charges of diesel and electricity STWs in the village were 1,800 taka and 1,500 taka per acre respectively, DTW owners demanded only 1,386 taka per acre, which is 8-23% lower than that of the STWs.

seems to explain why farmers are inclined to 'over-' invest in tube wells. In other words, individuals are behaving very 'rationally', but, as a result of it groundwater markets as a whole, are trapped in inefficiency, at least from the social point of view.

Groundwater Market in a West Bengal Village in 2000

A study village was selected from Nadia district, West Bengal, India and an in-depth study on groundwater market in the village (hereinafter referred to as Village D) was conducted in 2000. Nadia district is known as one of the major areas where groundwater irrigation by private tube wells rapidly developed since the 1980s.

Minimal issues directly relating to the topic of this paper will be selected and presented for discussion, especially in comparison with the Bangladesh cases already reported.

Outline of the Study Village

The study village is located about an hour journey by road northeast of the town of Kalyani, which is 2-3 hours from Calcutta by either vehicle or train (Map 1). When the preliminary survey was conducted in 1999, it had approximately 250 households living in its territory of about 360 hectares. The farm land was nearly 260 hectares, almost 100 per cent of which was irrigated by tube wells. The major cropping pattern was double cropping of rice; i.e. *aman* followed by irrigated *boro*, but in a relatively small elevated land, horticultural crops such as vegetables and banana were planted.

Evolution of Groundwater Markets

At the time of the survey in 2000, there are two state-operated DTWs and thirty one private STWs in the village.

The history of DTWs is quite long. They were constructed in April 1964. Both have been, from the beginning, electrified and the exploited water is distributed through the network of underground pipes. It means that the command area of each DTW is technically fixed. DTWs have been operated directly by the West Bengal State Government for more than thirty-five years. Although one operator and two assistants are officially nominated for each DTW and are paid, beneficiary farmers are continuously obliged to employ one operator in the irrigation season, since the official employees do not work at all. In addition to salaries, all the other operation and maintenance costs are born by the State. Farmers only pay a subsidized fixed water charge. For the task of problem-solving and necessary coordination, a beneficiary committee is organized, comprised of several key persons such as local official of minor irrigation department, chairman of *gram panchayat* office, operator, and representatives of beneficiary farmers.

The STWs can be classified into three; diesel STWs, electricity STWs, and submergible STW (hereinafter referred to as SM) and the numbers are three, 18, and 10 respectively. The SM is also operated by electricity and its motor is buried 60 feet below the ground. It is often referred to as mini-DTW because it exploits the groundwater below 180-200 feet, which is between 60-70 feet in case of STWs and 400 feet in case of DTWs.

According to information from elder intellectuals in the village, diesel STWs were gradually discarded from the mid-1970s and after the rural electrification program launched in the first half of the 1980s. Many electricity STWs were installed after that. Thus by the beginning of the 1990s, almost all the village farm land has been irrigated; but at the same time groundwater level began to decline gradually and farmers were obliged to convert existing STWs to SMs. The conversion to SMs started in 1992 and is still going on in the village. Table 52.12 indicates an extremely skewed distribution of tube wells, especially SMs, in favour of large farmers in Village D.

Table 52.12: Distribution of Tube Wells among Different Land Owning Strata in Village D, West Bengal in 2000

Land ownership strata (acres)	Diesel STWs	Electricity STWs	SM
0			
0.01-1.49			
1.50-2.49	1	3	
2.50-4.99	2	2	3
5.00-9.99		6	3
10.00-		2	2
Cooperative			1
Total	3	13	9
Average farm size of owners	2.72	6.54	7.00

A point that should be noted here is that the dominant contractual arrangement in groundwater market in the village was previously the seasonal tenancy of land by tube well owners with fixed in-kind (3 *maunds* of paddy per *bigha*) payment, which is exactly same as *Chaunia* in Village A, Bangladesh, although they did not call it there as *Chaunia*. However, from the mid-1980s water sales transactions with fixed cash payment increased gradually by replacing the seasonal tenancy, and by the time of the survey in 2000 it came to the situation that only cash water sales were observed. Some TW owners told me that then, even if they wished, farmers do not rent-out their land under the seasonal tenancy system. It seems that just as the case of Bangladesh, the contractual arrangement in the groundwater market is being 'modernized' and at the same time the real water price declined due to the increasing competitiveness of the market.

Profitability of Investment in Tube Wells

The result of analysis of the data collected is shown in Figure 52.4, which indicates that most of the tube wells, except for some SMs, which incurred a loss, show a more dismal picture than the case of Village C, Bangladesh in 1999. In addition, the increasing competitiveness among tube well owners, a special factor in the village that the conversion from STWs to SMs accompanies a sudden increase of irrigation capacity, should be taken into consideration. Namely, a SM has a capacity to irrigate about three times as much as land, compared to an electricity STW, so that when STW is converted to SM, it can deprive

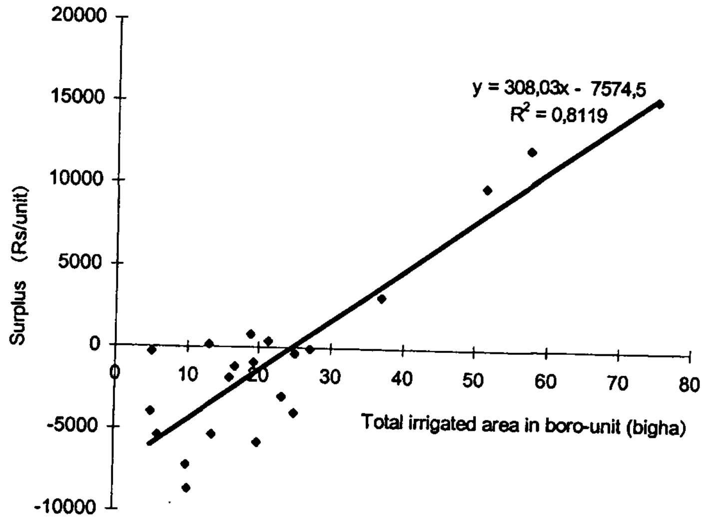

Figure 52.4: Profitability of Tube Well Investment in Village D, Bengal (2000)

of command areas from the other surrounding STWs, and jeopardizing their continuous operations.

Factor Shares in Rice Production

Table 52.13 summarizes the results of analysis of cost and return of *aman* and *boro,* based on interviews from the tube well owners. Some upper bias is involved in the sampling as before. But the comparison of operators' surpluses with the prevailing land rent in the village tenancy market showed that both are almost equivalent, which indicates a high reliability of the collected data.

Only two points will be raised from the table. First, in the case of irrigated *boro,* production, the share to water is 11 per cent, which is slightly lower than the case of Village C, Bangladesh in 1999 where it was 13 per cent. Considering that in Village D *Chaunia* (with the same rate of land rent) has long been a dominant system, it is very plausible that the sharp decline of real water price took place in our West Bengal village too.[8]

[8] Webster 1999 argued that tube well owners exploit agricultural surplus as 'water lords' in his study village in West Bengal, but he did not conduct any in-depth economic analysis. Our study shows a sharp contrast with his argument in the sense that many tub well owners actually incurred a loss due to the fierce competition among them, thus benefiting water purchasers.

Table 52.13: Comparison of Cost and Return of Rice Production between Bangladesh (1999) and West Bengal (2000)

	Aman				*Boro*			
	Village C Bangladesh		Village D West Bengal		Village C Bangladesh		Village D West Bengal	
Sample size	7		9		8		11	
Yield (*maunds/bigha*)	11.7	14.3	16.2	15.9				
(Per acre)	taka	Share (%)	Rs.	Share (%)	taka	Share (%)	Rs.	Share (%)
Gross revenue	10,545	100	9,690	100	12,916	100	10,890	100
Paddy	9,366		8,853		12,147		10,140	
Straw	1179		837		769		750	
Cost								
Seed	183		519		288		618	
Fertilizer	751		783		1,430		1,878	
Chemicals	0		204		67		207	
Sub-total	934	8.9	1,506	15.5	1,785	13.8	2,703	24.8
Labour	3,115	29.5	4,023	41.5	2,545	19.7	4,119	37.8
Irrigation	0		309	3.2	1,637	12.7	1,185	10.9
Interest on working capital	405	3.8	-	597	4.6	-		
Total cost	4,454	42.2	5,838	60.2	6,564	50.8	8,007	73.5
Net revenue (=land rent)	6,091	57.8	3,852	39.8	6,352	49.2	2,883	26.5

Note: 1 Rs= 1.21 taka.

Second, very importantly, compared with the Bangladesh case, it is evident that the share to labour is significantly larger at the sacrifice of the other production factors; especially land, in West Bengal. However, the reasons are not clear.[9]

Concluding Remarks

Several conclusions of this paper will be briefly summarized here:

First, in the study areas of north-western part of Bangladesh and of Nadia district, West Bengal, the groundwater market is 'saturated' within about one decade after private shallow tube wells started to be introduced at the beginning of the 1980s. At the initial stage, the rate

[9] The finding of our study coincides with Dasgupta (Dasgupta 1998), who argued that in West Bengal growth with equity was attained while it failed in Bangladesh. However, it seems that his explanation is also not persuasive enough.

of return to tube wells was relatively high and a large profit was accrued to the owners. However, the continuous increase of tube wells in confined areas afterwards made groundwater markets more and more competitive, resulting in a substantial decline of real price of water and a shrink of per tube well command area.

Second, in this process the major form of groundwater transactions shifted from seasonal tenancy of land by tube well owners to purchase of water from them by farmers.

Third, investment in tube wells became less and less profitable, making the argument of 'water lords' unrealistic.

Fourth, the share of land in irrigated *boro* (dry season rice) production, which decreased sharply in the initial stage (compared to traditional *aman* rice), experienced a substantial increase again with the shrink of the share to water.

Fifth, it is highly possible that the investment to tube wells is in excess and so inefficient from the social viewpoint, although individual farmers might behave rationally if transaction cost in water sales is taken into consideration.

Sixth, the continuous decline of groundwater level is forcing the tube well owners in West Bengal to introduce high-capacity submergible type of shallow tube wells (submergible pumps), resulting in necessary adjustments and arising conflicts in the village-level groundwater market, more than in Bangladesh.

Lastly, it is revealed that the factor share distribution in rice production is very different in Bangladesh and West Bengal; i.e. the share to land is significantly higher in the former than in the latter at the expense of the other factors; especially labour, although the reason is not clear enough and remains as an important future research agenda.

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