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IRRIGATION MANAGEMENT NETWORK

THE EQUITY IMPACT OF DEEP TUBEWELLS: EVIDENCE FROM THE IDA DEEP TUBEWELL II PROJECT

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Network Paper 12

April 1992

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ISSN: 0951 189X

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This paper is adapted from a longer project document 'The Equity Impact of Deep Tubewells', IDA/DTWII Working Paper 58. A shorter version was also presented at the Annual Conference of Bangladesh Agricultural Economists Association, BARC (Bangladesh Agricultural Development Corporation), 7-8 February 1991.

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1. INTRODUCTION

The development of minor irrigation, particularly through groundwater extraction, has played an important role in agricultural incomes and livelihoods. In the Fourth Five Year Plan continued reliance is to be placed on this sub-sector.

Of the technologies for groundwater extraction, shallow tubewells (STWs) give superior economic returns to deep tubewells (DTWs) due to their much lower capital costs per unit of water delivered, but are technically precluded from operating where static water levels are deeper than 20-25 feet. In addition to their high overhead costs, DTWs are also often criticised for their adverse impact on equity. It is argued that large farmers use their power to dominate irrigation decisions, take more than their share of water and divert any surplus from equipment operation to their own use.

This paper summarises the results of a study which estimated *quantitatively* the impact of DTWs on income of different farm size groups from crop production, wage employment and DTW 'ownership'. Data to estimate income flows from input supply of fertiliser and mechanical services are not available; accordingly, only the village level equity implications are considered.

The major conclusions are that large farmers ensure that a greater proportion of their land within the potential command area (PCA) receives water, but small farmers still do relatively better from the DTW because a higher proportion of their land is in the PCA and they use high yielding varieties (HYV) more. Production benefits considerably outweigh the surplus from equipment 'ownership', even when loans are not repaid.

Calculations were also made of increase in the demand for wage labour and, assuming wage increases similar to those reported elsewhere, on total wage income. Incremental wage income - going primarily to small (non-irrigating) farmers and the landless - was around 20-25% of the total benefits, more than the percentage accruing to large farmers.

2. DATA SOURCES

For this study, data from a number of sources have been used. Some use is made of the published literature; where so, references are cited. But most of the data has been generated by the DTW II Project either directly, using resources available to the project, or indirectly, through commissioned studies.

The Annual Evaluation Survey (AES)[1], despite its name, gathered data for only two years: 1986 and 1988. In 1988, six separate studies reported on work conducted in ninety villages, drawn from across the Project area, which covers thirteen districts around Dhaka and to its north. The villages were divided into three categories: 'old' villages, which had been covered by the 1986 studies; 'new' villages, where wells had become operational since 1986; and 'non-operational' villages, where loan approval had been given but the wells had not operated. Two reports - one covering 40 'old' villages, one 40 'new' - looked at well operation and KSS[2] performance; three reports, each covering 10 villages from one of the three categories, gave the findings of an intensive agro-economic survey of irrigating and non-irrigating farmers; one report, on the 30 villages where the ago-economic surveys were conducted, covered land tenure.

The AES of 1988 was the principal source of data for this study. Some use was made of data from the land tenure survey[3] and the Agro-Economic Survey of 10 'new' villages[4]; but the main source was the Agro-Economic Survey of 10 'old' villages[5].

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[1] Conducted for the BADC DTW II Project by Engineering Planning Consultants (EPC) Ltd.

[2] Bangladesh farmers' cooperative.

[3] EPC (1989a).

[4] EPC (1989b).

[5] EPC (1989c).

The survey was of eight villages chosen from the Brahmaputra-Jamuna flood-plain and two from the Madhupur tract, and elevated terrace with more weathered soils.

The Annual Monitoring Survey (AMS) has been conducted every year since 1987. The most recent completed report relates to the season 1988-89[6]. From the list of the 1812 Project wells reporting irrigation in the April 1989, every seventh scheme was chosen. Two separate questionnaires were used: one relating to KSS and well performance, the other to farmers costs and returns on crops irrigated by the DTW. Field level government staff acted as enumerators.

The results from the KSS questionnaire are used here to derive operational costs and revenues of tubewells and to calculate operational surpluses before loan repayment.

The Socio-Economic Impact Study (SIS) was an *ad hoc* study undertaken by an independent consultant with assistance from the DTW II Project. It was undertaken in April-May 1990 and covered six villages. Four of these had been covered in the Agro-Economic Survey (AES) of 10 'old' villages. A total of 114 irrigating farmers responded to a coded questionnaire and the results were entered in a database. The data collected have been used to supplement the AES data.

3. METHODOLOGY

Information on the distribution, between farm size categories of land and its irrigation source, if any, was given in AES (EPC, 1989) based on a census of ten villages where Project DTWs had been operating for more than three years. The farm size categories, used for this study, based on land *operated*[1], were as follows: small farmers - 2.5 acres or less; medium farmers - 2.5 to 5.5 acres; large farmers - more than 5.5 acres.

The crop production impact on farmers with different sizes of holding is measured by the difference between their situation 'with' and 'without' an IDA DTW. The 'with' situation was derived directly from AES data. Since

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[6] DTW II Working Paper 52.

[7] The AES report classification of households is by land operated, rather than land owned.

there was no baseline survey, the 'without' situation was calculated by assuming that the area irrigated by the Project DTW would otherwise have remained unirrigated.

It is recognised that in areas where STWs can operate this assumption would overstate DTW benefits. But the concern here is with the expected situation under the forthcoming National Minor Irrigation Development Project (NMIDP), where STWs and DTWs would rarely compete.

Land use in the 'typical' village was defined by assuming a DTW command area of 57 acres, the average acreage for the 1988-89 irrigation season. The area of land irrigated by other means and unirrigated land was calculated by assuming the ratio of such land to the DTW command area was similar to that reported in the villages covered by the AES.

AES data was then used to derive the 'with' and 'without' cropping patterns for different farm size categories. These were then used with the appropriate input-output and gross margin data to derive incremental impact on production, labour use and net income (full cost and cash cost) for each farm size category. Some fairly bold assumptions have been made in constructing these models and these are discussed in Appendices 1 and 2.

Farmers income was then adjusted to account for flows of income due to tenancy and for the rise in wage rates that are associated with the expansion of irrigation[8] (see Appendix 1). The corollaries of these were the flows of income to landlords (large farmers and absentees) and a calculation of the increase in wage income (accounting for price and quantity effects) going to small farmers and the landless.

Finally, a calculation was made of KSS income using AMS data (see Appendix 1). A weighted average of costs, income and loan repayments was taken. It was assumed that the whole surplus was divided among the large farmers.

[8] See Hossain, M. (1989) Green Revolution in Bangladesh, pp 102 and 105.

4. RESULTS

AES data[9] were used to derive: the cropping intensity (CI) on DTW land (156%), on other irrigated land (177%), and on unirrigated land for irrigators (182%), and on non-irrigators (170%); and the ratio of irrigated to unirrigated crops in the cropping patterns on irrigated land. Gross cropped acreage was then estimated for irrigated and unirrigated crops (see Table 3).

It will be noted that the introduction of the DTW results in a slight overall increase in CI, despite the CI being lowest on DTW land. This is because the CI of the unirrigated land of irrigators is higher than that of non-irrigators and, according to the assumptions of the model, many farmers who change category after the DTW is installed change cropping patterns and intensities correspondingly.

The cropping patterns for irrigators and non-irrigators in each size category were used, together with the corresponding output data, to calculate the impact on production. The outcome for the principal crops, taking all size categories together, is summarised in Table 1.

Overall the trade-off between rice and other crops is remarkably benign. This is because the substitution in the cropping pattern is not principally between rice and other crops, but between rice crops: B Aus, yielding 14 maunds/acre, for HYV boro, yielding 49 maunds/acre. Gains also come from the adoption of higher yielding T Aman crops.

Considering the distributional implications, most notable is the much greater degree by which small farmers increase their rice production. Partly this reflects the more dramatic jump in their area irrigated. But small farmers also show a greater preference for HYV over local variety (LV) or local improved variety (LIV) boro. Also notable from the AES data is that, contrary to the findings of other studies, the yields per acre for each crop are marginally lower for small farmers than for large. This may be attributable to lower recorded rates of fertiliser application[10] or an unquantified, but widely cited, tendency of large farmers to ensure that their land has priority in irrigation.

[9] Based on EPC (1989c) Table 11.1, pp 134-7, and Table 11.2, pp 138-9.

[10] See EPC (1989c), Table 15.535, p 159.

Table 1: Change in Production of Major Crops 'With Project'

	Small maunds	*%*	*Medium maunds*	*%*	*Large maunds*	*%*	*All maunds*	*%*
rice	1314	40.1	558	19.4	174	18.5	2046	28.8
wheat	-42	129.3	12	8.3	-4	-9.6	-3	-10.2
pulses	-6	-3.2	-31	-22.3	-14	-34.7	-52	-13.8
oilseeds	-17	-13.4	0	0	-2	-10.5	-19	-8.6
jute	-47	-19.0	-25	-14.8	-4	-5.5	-76	-15.6

Source: DTW II

Tables 2 and 3 below give the overall income flows using cash cost and full cost gross margins for crop production, respectively. It is argued that, of these two measures, the former is more appropriate for the purposes of a distributional analysis (see Appendix 2). It is true that small farmers, together with the landless, supply the vast majority of agricultural wage labour. So the additional labour demands from their newly irrigated plots will require them to forego wage-earning opportunities. But their withdrawal from the labour market correspondingly increases the employment available for the remaining wage labourers who come from a similar class, resulting in an intra-class income flow. Accordingly, the focus of the discussion below is on the results based on the cash cost gross margins.

Incremental crop production income dominates all other income flows. Income from tenancy to landlords represent the smallest flow, at 2.9%. Significantly, the 'returns' to KSS domination, even when calculated under relatively extreme assumptions, are only a small part (12.2%) of the total picture and are substantially less than the incremental returns to wage labour (21.3%).

Small farmers obtain nearly half of the incremental benefits from the DTW; medium farmers have second largest absolute share (16.3%). This is only fractionally larger than the share going to the landless (16.2%). Large farmers have come only third in absolute terms, with 15.8%. Absentee landlords come last, with only 2.2%.

Table 2: Incremental Income from DTW (Tk) - Cash Cost Gross Margin

	Crop Income	*Tenancy*	*Wages*	*KSS*	*Total*	*Total %*
landless	-	-	52968	-	52968	1.62
small farmers	145503	-	16752	-	162255	49.5
medium farmers	53388	-	-	-	53388	16.3
large farmers	9414	2416	-	40000	51830	15.8
absentee landlords	-	7250	-	-	7250	2.2
Total	**208305**	**9666**	**69720**	**40000**	**262181**	**100**
Total %	**54.5%**	**3.7%**	**26.6%**	**15.3%**	**100%**	

Source: DTW II

Table 3: Incremental Income from DTW (Tk) - Full Cost Gross Margins

	Crop Income	*Tenancy*	*Wages*	*KSS*	*Total*	*Total %*
landless	-	-	52968	-	52968	20.2
small farmers	103194	-	16752	-	119946	45.8
medium farmers	33940	-	-	-	33940	12.9
large farmers	5661	2416	-	40000	48077	18.4
absentee landlords	-	7250	-	-	7250	2.7
Total	**142795**	**9666**	**69720**	**40000**	**262181**	**100**
Total %	**54.5 3.7**		**26.6**	**15.3**	**100**	

Source: DTW II

These incremental income flows present a picture that is in sharp contrast to the widely held belief that large farmers, through their domination of KSS, are able to secure the bulk of the benefits from DTW irrigation. Large farmers still do well per acre irrigated but not as well as is often implied. It is valid to question the reasons behind this result.

4.1 Reasons for Relative Success of Small Farmers

Small farmers do well for two reasons: firstly, irrigating small farmers gain disproportionately from increased crop production; and secondly, the gains of small non-irrigators able to take advantage of increased wages and work opportunities in the Rabi season offset reductions in gross margins experienced by small farmers hiring labour. Their disproportionate gain from crop production deserves further mention. In part it reflected their greater disposition to grow HYV rather than LIV or LV boro and their considerably higher cash gross margins; these factors were fairly predictable. But it also reflected the fact that they benefit to a greater extent (compared to their total land holdings) from the DTW. This is surprising and contrary to the weight of anecdotal evidence that large farmers often bias DTW siting to their own land and then dominate management of the well to ensure that all their other land within the PCA receives irrigation.

The explanation of this 'perverse' result is to be found in the dispersion of landholdings in the utilised command area (UCA) and inside and outside the PCA (see Table 4). Large farmers do manage to obtain irrigation for a larger proportion of their land within the PCA[11]: the UCA/PCA ratio is 0.83, compared to 0.71 for small farmers. This is in accordance with the anecdotal evidence. But more than compensating for this bias, they hold a smaller percentage of their land in the PCA: 25.5% compared to 41.9% for small farmers. Consequently, they irrigated a smaller percentage of their total land.

Why large farmers should hold a smaller percentage of their total land in the PCA is not certain. It could be a statistical anomaly, but the AES study of 10 'new operational' DTW KSS villages reflected the same pattern[12]. One explanatory hypothesis is that with highly fragmented and dispersed holdings, farmers forced to sell land will *ceteris paribus* dispose of plots farthest from their homestead. Small farmers would thus dominate the land adjacent to settlements - which is where DTWs are often sited for security reasons.

Medium farmers do poorly, relative to their numbers and land holding, because: the impact on their irrigated holdings is less dramatic; they employ considerably more labour than small farmers and have lower cash gross

[11] Derived from EPC, op cit, Table 7.1, p 123.

[12] See EPC (1989), Land Tenure Survey of IDA DTW KSS Villages, Table 7, p 31.

margins; and, according to the assumptions made, they do not share in the benefits from KSS domination.

Table 4: Total Land (%) Distribution Relative to Command Area

Farm Category	*UCA % **	*Inside PCA %*	*Outside PCA %*	*UCA/FCA Ratio*
small irrigators	29.8	41.9	58.1	0.71
medium irrigators	20.2	28.0	72.0	0.72
large irrigators	21.2	25.5	67.2	0.72
Total	**25.0**	**34.7**	**65.3**	**0.72**

* UCA is a sub-set of PCA.
All percentages are of total landholdings.

Source: Based on EPC, op cit, Table 7.1, p 26 and Table 1 above.

Large farmers do less well than expected for a number of reasons: first, though they are able to ensure that more of their land in the PCA is irrigated than that of other farmers, they hold a smaller proportion of their land there, and so the DTW irrigates a smaller proportion of their total land. Second, they are more inclined to grow LV or LIV boro, which has much lower yields than HYV. Third, they hire considerably more labour than smaller farmers and so have lower cash gross margins and suffer more than other groups from any increase in wages resulting from the DTW. Per acre irrigated, the 'returns' to KSS domination compensate for this; but since these returns are so much lower than the benefits accruing from crop production, not sufficiently to allow large farmers dominate incremental income flows.

5. CONCLUSIONS

There is clear evidence from the relative percentages of land within the PCA receiving irrigation, that large farmers are able to secure for themselves a disproportionate share of irrigation water (see Table 3). This confirms many verbal reports and some field case studies[13]. There is also an overwhelming weight of anecdotal evidence that many large farmers are happy to treat any surplus KSS funds as their own and feel no strong inclination to reduce that surplus by making repayments on the DTW loan.

These are sources of concern for both government and donors, but the problem should be placed in the context of both the distribution of other income flows arising from the DTW and the other potential forms of government supported investment in rural areas.

An assessment of specific alternatives to DTWs has no place in this paper, but a number of studies[14] have indicated the ease and ruthlessness with which local elites may capture the benefits of government sponsored schemes intended for other groups. Thanks to land fragmentation, this is harder to achieve with a DTW, where the largest category of benefit - from crop production - must be shared by all land owners within the UCA.

Improvements can be made in the distributional impact of DTWs through increases in: command areas, to encompass land (usually belonging to small farmers) in the PCA that remains unirrigated; KSS membership and their influence over the disposal of KSS funds; and loan repayment rates. But, the overall impact on equity of DTWs is considerably more positive than is recognised by many commentators. And, where STWs are unable to properly exploit groundwater resources, perhaps superior in both economic and distributional terms to many alternative forms of government intervention in rural Bangladesh.

[13] For instance, Jansen (1989), Rural Bangladesh: Competition for Scarce Resources, p 152.

[14] See Hartmann and Boyce (1979) Needless Hunger: Voices from a Bangladesh Village, and Jenkins, et al (1980) The Net: Power Structure in Ten Villages.

APPENDIX 1

Other Sources of Income

1.1 Landlords Income from Tenancy

The AES collected a considerable amount of data on tenancy relations in the 10 villages. Land share-cropped, leased or mortgaged in and out by each stratum is detailed, revealing a complex set of relations[15], similar to those found by Jansen (1987). The conditions attached to these tenancy contracts also varies, even quite locally. For instance, in Glaser's study[16] in six villages found eight named types of tenancy, with conditions varying over lease cost, duration, cost sharing, conditions for the return of land, etc.

To quantify the implications of tenancy on income flows it was necessary to abstract from many of these complexities. In the calculations, only the *net* tenancy position of each size group was considered: the tenancies of medium farmers balanced; small farmers as a group were net tenants, on around *9%* of their land[17]; the net landlords were large farmers (25%), and absentee landowners (75%). Mortgages were less frequent and subject to widely varying conditions, so it was assumed that all tenancies were share cropping. Tenancy was taken to be for the full year, with gross returns from all crops being divided equally. Cash costs of cultivation were ascribed to the tenant, except for boro rice. For boro, where the landlord may bear up to half the costs[18], 75% of costs were ascribed to the tenant. Income was recalculated for small farmers assuming that 9% of their land was subject to these conditions. This was divided among the landowners *pro rata* to their net tenancy position.

[15] See EPC (1989c) Table 6, p 122.

[16] See Glaser, Socio-Economic Impact Study.

[17] Net figures are used because the overall effect on the group is the focus of the study.

[18] See Glaser, ibid.

1.2 Impact on Water Income

With the introduction of the DTW, both the quantity of labour demanded and wage rates increase.

To calculate the change in the quantity of hired labour demanded, the cropping pattern model was used, together with data on hired labour use for each crop by irrigators and non-irrigators in each size category. Predictably, there is a seasonal shift from early to late Kharif, and Rabi.

Those irrigating from other sources are assumed to have the same input coefficients for hired labour use in both the 'with' and 'without' DTW situations. But Hossain has noted that, with greater prosperity from irrigation, farmers tend to substitute wage labour for their own labour in farm operations[19]. Irrigating farmers would therefore be expected to use a lower proportion of hired labour in the 'without' situation. The assumption of fixed coefficients for hired labour thus probably results in an under-estimate of the increase in demand for hired labour.

To include the effect of changes in wage rates in the calculations, two symmetrical effects must be introduced: an increase in income going to wage labour, and a decrease in incremental gross margins for farmers employing wage labour.

Hossain found that a comparison of developed and under-developed villages suggested that technological progress has a positive effect on the wage rate. For male workers, the agricultural wage rate in developed villages was 19% higher than in under-developed villages[20]. The AES also reported an increase in wages for casual labour for the peak operations in the boro season[21]. The survey conducted for SIS indicated increases in real wages of the order of 50% following the introduction of the DTW, but wage rates quoted varied and the quantity of labour employed was not recorded, so it was not possible to calculate a weighted average. Accordingly, a wage increase of 20% (in line with Hossain) has been assumed.

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19 See Hossain (1989), p 102 and Table 56, p 105.

20 See Hossain (1989), p 99.

21 See EPC (1989c).

1.3 KSS 'Income'

Though tubewells are owned by their cooperatives, there are a number of avenues for personal enrichment, ranging from misunderstandings by the KSS membership of their rights to straightforward theft. Examples include: refusal to pay dues; the division of any operational surplus among a select clique (often those contributing to the downpayment on the loan); and misappropriation of the monies designated for loan repayment.

These *ultra vires* income flows are of particular relevance to any discussion of the equity impact of tubewells because it is predominantly the powerful who exploit such opportunities with impunity. The issue of KSS domination by local elites has received much attention in the literature and its variations and mechanics will not be further elaborated here. But to gain a sense of its proportion to the other income effects of the tubewell, these flows need to be quantified.

Costs vary with power source - diesel or electricity - and average Tk 48,885. DTW operational revenues are dependent on the area irrigated, the water charges levied and the rate of repayment. As before, a command area of 57 acres is assumed. Water charges vary according to method of collection of loan repayment contributions and water charge payment method. Where payments are made in cash, water charges for irrigated (non-beel) boro rice averaged Tk 975 per acre (excluding loan repayment contributions), and Tk 1,420 per acre (including loan repayment contributions)[22]. Where crop-share is used, the near universal norm is for 25% of the crop to be taken. With a yield of 48 maund/acre and a price of Tk 203/maund, this gives a cash equivalent water charge of just under Tk 2,440 per acre. The ratio of crop share to cash schemes is 30:70. If the higher cash water charge is taken, this gives a weighted average water charge of Tk 1,726 per acre and a projected revenue for the 'average' scheme of Tk 98,380. Not all of this will be collected by scheme management. Though the repayment rate on crop share schemes was good, for schemes collecting their water charges in cash, 42% of irrigators had not repaid their water charges in full by the end of September[23]. However, because it may often be the larger farmers who do not pay, non-payment of water charges will be ignored here in the calculation of operational surplus.

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22 DTW II Working Paper 52, Table 2.7, p 14.

23 DTW II Working Paper 52, Table 2.9, p 15.

This would give an initial surplus of Tk 50,000. An average scheme will make some repayment to the bank - 35% of instalments due were reported as repaid in AMS89[24]. This would represent a payment of Tk 9,240 on the weighted average instalment of Tk 26,396[25]. This leaves Tk 40,000 available for non-accountable distribution.

For obvious reasons, no hard information is available as to how mis-appropriated funds are divided among irrigators belong to the different farm size groups. However, there are reasons to believe that the rewards are spread. For crop share schemes, the financiers of the DTW's seasonal variable costs expect to share any operational surplus. The average number of financiers reported in AMS89 was 15[26]. Those who contribute to the initial downpayment are also seen as being entitled to a share. The obligations that exist between members of the *same gusti* would also indicate that large farmers, however much they might dominate KSS decisions, would feel obliged to share the operational surplus from well operation with other households. *Nevertheless, in the calculations, it is assumed that the entire operational surplus of Tk 40,000 is divided among the large farmers.*

[24] DTW II Working Paper 52, Table 2.15, p 21.

[25] DTW II Working Paper 52, Table 2.14, p 20.

[26] DTW II Working Paper 52, Table 2.5, p 11.

APPENDIX 2

Reasons for Using Cash Costs

AES provided data on cash cost and full cost gross margins. (The latter adjust cash costs to attribute the market value to inputs - mainly labour - supplied free by the fanners own household.) The difference is important, particularly for the small farmers, who hire little labour.

Cash rather than full cost gross margins were used for two reasons: first, because the latter are highly misleading when there are, for much of each season, high levels of underemployment at prevailing wage rates; and second, and more importantly, because of the distributional focus of the study. It is true that small farmers, together with the landless, supply the vast majority of agricultural wage labour. So the additional labour demands from their own irrigated plots will require them to forego wage earning opportunities. But the withdrawal of their labour from that market represents as much a gain for others (of a similar class) as a loss for themselves. Since the focus of this study is the accrual of benefits to size classes rather than to individuals, the loss of wage income by some small farmers is taken as an intra-size class redistribution, and therefore ignored.

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