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DETERMINATION OF COST OF TUBEWELL WATER AND ESTIMATION OF CANAL WATER SUBSIDY IN PAKISTAN

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By

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The main purpose of this paper is to ascertain if there is any implicit subsidy involved in canal irrigation water supply in Pakistan. If the public cost to supply surface irrigation is higher than the water rates assessed for any crop, irrigation is deemed subsidized by the state (13). The public cost of irrigation is normally constituted by interest on capital and running expenses of the canal system whereas water rates are a statutory payment fixed for the supply of more or less optimum water requirements to mature an acre of a given crop. The existence of the canal irrigation subsidy at a given time may thus be established by a comparison of current water rates with the public cost of canal water supply or with the cost a cultivator will bear in securing irrigation water from a well with bullocks or from a tubewell. The cost of obtaining a certain quantity of water from tubewell reflects the commercial value of the same volume of canal withdrawal. If the allernate cost of obtaining water from my source is in excess of that associated with public irrigation water supply, there is a room for additional charge on irrigated agriculture (17). In this study, the question of subsidy has been investigated by following the second alternative approach in which the cost of fulfilling the standard water requirements of different crops from a private tubewell is compared with respective water rates. This approach has the advantage of being relatively less complicated and can afford periodical verification of commercial value of irrigation due to small time and data requirements. Conversely, a regular estimation of cost of surface water supply is rendered difficult by inadequate information regarding service life of the complicated canal network and accounting of irregularly ascendin

recurring expenses as well as repair of unpredicatable flood damage or natural collapse of irrigation structures.

The estimation of the subsidy by measuring the commercial value of canal irrigation on the basis of tubewell water cost is further prompted by the fact that farmers with inadequate or no surface supplies resort to ground water for irrigation either by investing in tubewells or purchasing its water. It implie that farmers with insufficient or no customary water supply due to them from canal would purchase surface water, if it is marketed, at approximately the same price at which the tubewell water is sold in the area. It has been observed that farmers frequently supplement surface water supplies when necessary and a decrease in canal water supply has been accompanied by an increase in the use of groundwater (15). More specifically, 60 percent of the sample farmers located in central Punjab were found to purchase tubewell water upto 42 percent of their canal water supplies during Kharif whereas 64 percent farmers bought upto 45 percent of their surface supplies during Rabi season of 1965/66 (14). Farmers have also been found to pay in kind as payment upto 33% of crops raised on tubewell water supplies (6).

The cost of production of tubewell water and its economic effects have been examined by Punjab Board of Economic Enquiry (3,4), WAPDA (18), Ministry of Food and Agriculture (6) and Hazara Engineering Co. (10) from survey data of private electric and diesel units scattered in various districts of Punjab. Similarly, IACA (11), IBRD (12) and Ghulam Muhammad (15) estimated cost of water delivery from Public SCARP tubewells which operate only on electricity and have higher discharge capacity than private tubewells. All these studies, without exception, reported higher cost of delivering water from diesel compare to electrically operated units of equivalent discharge capacity. The public tubewell water cost per acre foot has been found to be significantly higher

than that of private tubewell running on the same motive power. The use of tubewell water both in isolation and in integration with surface supplies has shown a very favourable impact on farm productivity, cropping patten, employment of human labor, use of animal power and application of other modern inputs. However, no study has used the cost of tubewell water as a basis to determine the cost of surface supplies and thereby to estimate the canal irrigation subsidy implicity appropriated by the farm sector. Nor is there any study that has attempted the estimation of the subsidy in surface irrigation in any alternative manner.

The size of the subsidy in canal irrigation water will reflect the relevance of current water rates. Since the study in the process of the subsidy estimation will first determine the cost of a Private tubewell water which is otherwise important to know the requirements of capital and to design credit policies to develop this source of irrigation.

DATA AND METHODOLOGY

The data were obtained from a survey of tubewell equipment selling firms located in metropolitan Lahore. In all, 25 firms were contacted for data on prices of the entire array of components required to install tubewells with 1, 1.5, and 2 cusecs discharge capacity, during a ten-days period from 4 to 14 August 1977. Five out of these firms also provided information on drilling operations of tubewells. The data on drilling operations was augmented with information from four additional firms that specialized in tubewell boring. The running expenses and operational hours were estimated from analysis of 139 diesel and 120 electric private tubewells selected from a nationwide tubewell survey carried out by the University of Engineering and Technology, Lahore in 1974. The diesel tubewells were categorised as 2 with 1, 66 with 1.5 and 49 with 2 cusecs capacity whereas

the electric tubewells were distributed in the order of 36 with 1,49 with 1.5 and 35 with 2 cusecs discharge.

The operational expenses of private diesel and electric tubewells were estimated in the form of fixed cost and variable cost. The fixed cost was constituted by interest on installation outlay and depreciation of tubewell machinery as well as masonary work. Interest cost was determined at a market rate of 12 percent. Depreciation of tubewell equipment and masonary work was , however, calculated at the rates of 10 and 3 percent respectively.

The variable expenses comprise costs of diesel, power, lubricants, spare parts, repair, maintenance, and pay of the oper-ator. The running expenses which pertained to 1974 were adjusted upwards with relevent price indices to account for any price inflation for the intervening period upto 1976. More specifically, the cost of diesel was adjusted with the index on fuel and lubricants, power consumption bill with the index of electricity and the remaining expenses with the general wholesale price index.

The production cost of tubewell water per hour was derived by deflating the total operational expenses on annual hours of operation. The cost per acre foot or per acre inch of water was estimated, on the other hand, by dividing the total expenses with volume of water delivered in these hours. Finally, the subsidy involved in canal irrigation of individual crops was determined as below:

$$SCI = \left[\frac{TC}{AI}\right]\left[WD\right] - WR$$

Where,

SCI = Subsidy in canal irrigation of an acre of a given crop
TC = Total cost of operation per annume of a given tubewell
AL = Total volume of water delivered in acre inches by the tubewell during its operation period in a year[a]
WD = Water delta in acre inches required to mature an acre of the crop
WR = Water rates per acre for the crop

(a) Total volume of water delivered in acre inches can be measured as:

$$\frac{(60)\ (60)\ (\text{Discharge level})\ (\text{Annual operational hours})\ (144)\ (12)}{(4840)\ (9)\ (144)}$$

The irrigation subsidy as measured above was compared with its alternate estimation based on the water contribution to crop output value. The irrigation contribution was denoted by a proportion of 35 percent of crop revenue as suggested by the Ministry of Food and Agriculture (6). The published data on yields and wholesale prices of farm commodities for 1976-77 were used to derive the share of irrigation. Actually, only a fraction of the irrigation contributions is charged as water rates. The amount that may be appropriated as water rates was calculated at the rate of 35 per cent of the pecuniary benefits attributable to irrigation. This proportion has been adopted from the water rate fixation criterion enunciated by the National Council for Applied Economic Research (16). Finally, the subsidy is estimated as a residual of the amount that should be taxed away as water rates minus water rates actually charged.

Symbollically, the method may be expressed as below:

$$SCI = \left(\frac{Y}{D} \cdot K\right) - WR$$

Where,

SCI = Subsidy in canal irrigation of an acre of a given crop.

Y = The output value per acre of the crop

D = The factor denoting per cent share of irrigation in total output value per acre of the crop

K = The factor denoting a percentage of irrigation benefits to be taxed away as water rates per acre

WR = Water rates per acre for the crop

RESULTS DISCUSSION

Fixed, Variable and Total Cost of Operation

The components of installation and operational costs of a private

diesel and electric tubewells are depicted in table 1. The total installation outlay varied with the quality of tubewell material, depth of boring and discharge capacity. A tubewell with a higher discharge level necessitates the installation of a relatively large centrifugal pump, bigger diesel engine/electric motor and longer pipes with wider diameters. This is precisely why there is a conspicuous difference in installation costs of tubewells with variable discharge capacity. However, the difference between the initial investment of 1.5 and 2 cusecs tubewells is markedly higher than the difference in the costs associated with units of other discharge capacity. The reason for the disproportionate difference in the capital cost of the two upper than the lower discharge level tubewells is that in high water table areas 1 and 1.5 cusecs tubewells are fitted with more or less the same equipment except that a centifugal pump with enlarged impeller is used in the latter type of well. This small modification does not entail any significant difference in cost. However, the cost of installation of these discharge level tubewells is significantly different in areas of deep water table involving longer "draw out" which requires relatively more powerful engines/motors for higher discharge tubewells. Still another reason for the relatively smaller difference in the total investment cost of 1 and 1.5 cusecs wells is that, within a certain range, the cost of the smaller of the same two parts is higher due to difference in labour input needed to achieve precise finish.

Fixed cost, as would be expected, rose with the increase in tubewell discharge. Although per hour fixed costs of a diesel tubewell ascended with an increase in discharge level, the difference in costs associated with 1.5 and 2 cusecs tubewells is negligible due primarily to significantly higher intensity of operation observed in the latter

Table 1: TOTAL, FIXED AND CURRENT COSTS IN RUPEES OF A PRIVATE TUBEWELL

Cost	Diesel Well			Electric Well		
	1. cusec	1.5 cusecs	2.cusecs	1. cusec	1.5 cusecs	2. cusecs
Installation Cost						
.) Tubewell equipment	19,488	23,328	31,017	9,090	12.083	17,684
.) Masonary work	6,000	6,000	6,500	3,500	3,500	3,500
.) Non-capital expenditure	2,671	2,791	3,301	2,694	2,814	3,308
Total:	28,159	32,119	40,818	15,284	18,397	24,492
Fixed Cost						
.) Interest on installation cost @12%	3,379	2,854	4,989	1,834	2,208	2,939
.) Depreciation on tubewell equipment @10%	1,948	2,333	3,102	909	1,208	1,768
.) Depreciation on masonary work @ 3%	180	180	195	105	105	105
Total:	5,507	6,367	8,195	2,848	3,521	4,812
Variable Cost	13,882	1 ,386	16,084	8,496	10,092	10,433
Total operational cost	19,389	1 ,753	24,279	11,344	13,613	15,245
Sample tubewells	24	66	49	36	49	35
Total operation hours	2,956	2,179	2,728	2,390	2,335	3,200
Fixed cost per hour	1.86	2.92	3.00	1.19	1.51	1.50
Variable cost per hour	4.70	5.23	5.90	3.55	4.32	3.26
Total cost per hour	6.56	8.15	8.90	4.74	5 83	4.76
Pumpage in acre feet	244	270	451	198	290	529
Fixed Cost per acre foot	22.57	23.58	18.17	14.38	12.14	9.10
Variable cost per acre foot	56.89	42.17	35.66	42.91	34.80	19.72
Total Cost per acre foot	79.46	65.75	53.83	57.29	46.94	28.82

Source : Appendix A.

form of tubewells. Similarly electric wells of 2 cusec discharge were found to be operated for longer hours and therefore the fixed cost per hour reduced to the level associated with tubewells of lower discharge despite a great difference in this capital outlay.

The variable cost per hour varied directly with the level of discharge of diesel tubewells. The positive association between the variable cost and discharge capacity is attributed primarily to the difference in the consumption of diesel which accounts for the bulk of the running expenses, and employment of operators. The consumption of diesel hovered around 0.5 gallon per hour in 1 cusec, around 1 gallon in 1.5 cusec and over 1 gallon in 2 cusec tubewells. Bigger tubewells run by operators were normally installed by large landowners. The variable cost of an electric tubewell, on the other hand, increased only when discharge level rose from 1 to 1.5 cusecs and declined on its increase to 2 cusecs. The main reason for such a pattern of variable cost is the consumption of power, which represents the highest proportion in current expenses of these tubewells. The rate of its consumption increased by a higher margin when the discharge level rose from 1 to 1.5 cusecs than when it increased from 1.5 to 2 cusecs. In certain instances, the cost of spares contributed significantly to the variable cost. However, in general, the consumption of diesel and power were more significant, than any other factor in determining the running cost.

The average variable cost based on combined expenses of all discharge level diesel tubewells came to Rs. 5.26. It compares with Rs. 3.34 reported by the Ministry of Food and Agriculture during 1972 (6) and with Rs. 3.79 estimated by the Board of Economic Inquiry in 1965 (3). The per hour average variable cost derived from collective expenses of electric tubewells of all discharges, on the other hand, was observed as Rs.3.66 compared

to Rs. 1.98 and Rs. 1.62 found by the above agencies for private electric tubewells. The average total cost per hour estimated on the same line as variable cost amounted to Rs. 7.54 for diesel and Rs. 5.07 for electric tubewells. During 1975, the Board of Economic Inquiry in its second study (4) reported the total cost per hour as Rs. 8.31 for diesel and Rs. 3.73 for electric units.

The intensity of operation of tubewells, besides initial investments, affected significantly the total cost per hour. Tubewells in rice growing district were operated for higher number of hours during kharif than in other parts of the year. However, for the Punjab as a whole the intensity of operation did not exhibit any noticeable difference between seasons. Diesel tubewells with one and electric tubewells with 2 cusecs discharge were operated for relatively longer hours than the remaining discharge level tubewells. The difference in the intensity of operation of these discharge level tubewells is attributed to the location and the size of land holding on which they were installed. The electric tubewells were concentrated largely in the rice belt where high discharge units were found to operate more intensively. Conversely, relatively a larger number of 1 cusec diesel tubewells located in wheat-cotton area were operated more intensively.

The fixed, variable and total costs per acre foot costs per acre foot were negatively related to the level of tubewell discharge. By comparison, these costs per acre foot were significantly lower on electric than on diesel wells of equal discharge capacities. Specifically, the total cost per acre foot of water obtained from 1 cusec diesel tubewell came to Rs. 79.46 compared to Rs. 57.29 for an electric tubewell of corresponding discharge. The total cost of pumping dropped by 32 per cent in diesel and 50 per cent in electric tubewell, respectively, on the increase of discharge level from 1 to 2 cusecs

due to the economy of scale. Total variable cost and fixed cost per acre foot declined, as would be expected, in about the same proportion when the tubewell delivery rate rose from 1 to 2 cusecs. The aggregated pumpage of all discharge level diesel and electric tubewells were associated with variable cost of Rs. 42.85 and Rs. 28.54 per acre foot respectively. However, average total cost determined by collective volume of water was observed as Rs. 63.65 for diesel and Rs. 39.53 for electric units of all discharge levels.

The pumping cost of tubewell water supply has increased considerably over the years. Previously, WAPDA (18) estimated the cost of an acre foot of water as Rs. 14.49 and Rs.20.93 for private electric and diesel tubewells. Similarly, Hazara Engineering Co. (10) reported Rs. 28 as the per acre foot cost of a private diesel and Rs. 19 of an electric unit. Later, IACA (11) and Ghulam Muhammad (15), working independently, determined the same cost of Rs. 24 per acre foot of groundwater pumped by diesel and Rs. 16 by electric tubewells at private farms. The Ministry of Food and Agriculture (6) recorded Rs. 26.69 and Rs. 17.96 as the costs to pump the same volume of an acre foot of water from private diesel and electric tubewells. More recently, however, the Punjab Board of Economic Inquiry ascertained the cost of delivering an acre foot of water from diesel tubewells as Rs.99.72 and from electric tubewells as Rs. 44.82 (4).

As a way of recapitulation, all the three forms of operational costs- fixed, variable and total costs- estimated in terms of per hour and per acre foot were significantly higher for diesel than for electric tubewells. During the period around 1965, fixed cost and variable cost accounted for approximately an equal share in the total operational expenses of either type of tubewell. However, the recurring expenses since 1970

have outraced the fixed cost component. Although the installation and operational cost have revealed a considerable increase over the years, the rise in expenses may be viewed in relation to the increases in farm prices. Since both the tubewell expenses and farm product prices have withnessed increases simultaneously, although not in precisely the same proportion, tubewells operation does not appear to have been adversely affected. Although some concern has been expressed about diesel prices and its availability, supplies of fuel and lubricants have never fallen to the distressing level.

The problem of field performance of tubewells is largely unknown to the farmers. Although the performance of tubewells is expected to decline with the efflux of time, the efficiency has been recorded much below the rated level even at very early stages of their operation (2). The main reasons of rapid decline in the efficiency of tubewells over time are the poor quality of material, unsatisfactory precision of finish and imperfections of installation. Diverse brands of tubwells components are being marketed by a variety of firms who hardly adhere to any standard specifications. It was observed in the market survey that no single firm sells a complete set of tubewell components but every firm claims the ability to assemble the entire unit. Obviously, it is done by picking up parts from other firms in the business. Such a collection of components made by diverse firms allows a possibility of imperfections. This is where instantaneous state intervention is called for introduction of scientifically determined rigid specifications in the manufacturing of tubewell equipment. An increase in both efficiency and operational hours drives the cost per acre foot of water down. It is belived that the efficiency can improve considerably but only if rigid standards for the manufacturing of tubewell equipment are introduced and the compliance in closely watched. The quality equipment

will increases the operational hours by reduction in running faults. Tubewell ownership was found largely a phenomenon of single ownership on relatively large holdings. Joint ownership of tubewells is virtually non-existent. A change towards collective ownership to increase commanded area will perhaps stimulate increased intensity of operation and thereby some reduction in operational expenses.

Cost of Crops Standard Water Requirements and Canal Irrigation Subsidy

The optimum water requirements of differents crops reveal wide variations depending upon the gestation period and plant growth patt rn. The diversity on optimum water delta is reflected in the cost of tubewell irrigation. Ordinarily, the cost of water to mature an acre of a crop varie directly with its recommended level of irrigation water. The cost of diesel tubewell water to fulfil the standard irrigation requirements varied from a maximum of Rs. 361 for sugurcane to a minimum of Rs. 45 for oilseeds base on the collective pumpage of all discharge level. The average cost of tube water per cropped acre of the major crops considered in table 2 amounted to The cost of electric tubewell water to supply the same water delta, on the o hand, ranged fromRs. 224 for sugarcane to Rs. 33 for oilseeds and average to Rs. 112 per acre.

The amount of the implicit subsidy received in canal irrigation of a crop varies directly with its water delta because water rates, which constitute a basis for its estimation, do not appear to exhibit any precise correspondence with the rate of water use. For instance, water rates charg for rice using 64 acre inches of water are Rs. 16.86 whereas they amount to Rs. 16.00 for cotton that consumes only 25 acre inches of water in about the same span of crop season. Conversely, water rates for cotton and maize are different for use of the same 25 acre inches of water. As such the implicit

Table 2: Cost of Tubewell Water for Major Crops and Estimation of Subsidy per Acre of Canal Irrigation.

Crop	Standard Water Delta (Acre Inches)	Canal Water Rates (Rs.)	Diesel Well		Electric Well	
			Cost	Subsidy	Cost	Subsidy
Wheat-Mexi-Pak	18	10.40	95	85	59	49
Rice-Irri	64	16.86	339	322	211	194
Sugarcane	68	35.60	361	325	224	188
Cotton	25	16.00	133	117	82	66
Maize	25	9.60	133	123	82	72
Potatoes	40	20.00	212	192	132	112
Onion	30	20.00	159	139	99	79
Tobacco	25	16.86	133	116	82	65
Oilseeds	10	7.64	53	45	33	25

Source: Derived from survey data.

Note: (a)Data on water delta obtained from Minisry of Food and Agriculture Planning Division, Islamabad.

subsidy as represented by the difference between the tubewell water cost assumed to denote the commercial value of surface supplies and the relevant statutory water rates depends more or less entirely on specific water delta of field crops. Consequently, its occurrence in canal irrigation of sugarcane and rice crops, indicating peak water requirements, is much in excess of that involved in any other crop. More specifically, the amount of the subsidy fluctuated from a maximum of Rs. 325 per acre of sugarcane to a minimum of Rs. 45 for oilseeds consequent to diesel tubewell water cost. The average amount of irrigation water subsidy was observed as Rs. 163. As would be expected, the subsidy appropriated in each crop was smaller by a significant margin where the pumping cost of electric tubewells was assumed to reflect the commercial value of surface irrigation. The size of the subsidy was recorded as varying from Rs. 198 in rice to Rs. 25 in oilseeds with an average of Rs. 94 per acre of major crops. By comparison, the amount of subsidy assessed, with respect to electric tubewell water cost, for individual crops as well as per acre of all crops considered in the study is less by about 40 per cent.

The estimation of the canal irrigation subsidy carried out with the method of crop output value is depicted in table 3. Since this procedure yields the subsidy as the difference between the proportion of crop output value attributable to irrigation and prevalent water rates, the market value of the crop assumes a critical role in its determination. High-value crops are associated with high level of subsidy and vice versa. Specifically, sugarcane, rice, potatoes, onion and tobacco appropriated relatively higher irrigation subsidies. The empirical data on product value and water require show that improved varieties are normally highly subsidized. The subsidy ranging from Rs. 50 for oilseeds to Rs. 507 for potatoes averaged to Rs. 23 per acre under the current market prices of the major crops. High-value cr will continue to appropriate higher levels of irrigation subsidy as long as

Table 3: Canal Irrigation Subsidy Per Acre Based on Water Contribution in Crop Output Value

Crop	OutPut Value (Rs.)	Contribution of Water (a) (Rs.)	Amount for Taxing (b)	Water Rates (Rs.)	Subsidy (Rs.)
Wheat Maxi-Pak	690.00	241.50	84.53	10.40	74.
Rice Irri-Type	1139.40	398.79	139.58	16.86	123
Sugarcane	2807.60	982.66	343.93	35.60	308
Cotton	722.72	252.95	88.53	16.00	73
Maize	595.14	208.30	72.91	9.60	63
Potatoes	4305.00	1506.75	527.36	20.00	507
Onion	3870.10	1354.54	470.94	20.00	451
Tobacco	4091.22	1431.93	501.17	16.86	484
Oilseeds	481.04	168.36	58.93	7.64	50

Source: Statistical Year Book 1976 and Agricultural Statistics of Pakistan 1975.

Note: (a) 35 per cent of crop output value has been attributed to irrigation water.

(b) 35 per cent of the amount attributable to water is considered to be taxed away rates.

their yields stay high because the income depressing effect of market price fluctuations has been obviated by output price support programmes. It means that the acreage of such crops as are covered under such programmes is not expected to decline as long as their prices are prevented from subsiding below a certain level. Alternatively stated, farm income due to major crops has been stimulated to grow at a stable rate on increased use of irrigation and other cooperant inputs such as fertilizers, pesticides etc.

Farming in Pakistan has profoundly been affected by climatic variations and inherent physical endowments especially irrigation water sup Consequently, specific crops thrive in specific regions in particular rotati Thus, the assessment of canal irrigation subsidy involved in particular crop rotations may also be interesting. For this purpose, four crop rotations prevalent in most of the rice and wheat belts of Punjab have been considered The respective amounts of subsidies have been indicated in table 4. The average subsidy per acre for rice zone crop combination was in excess of that for wheat zone because the crops raised in the former region are simultaneously heavy water delta and high market value crops. The size of average subsidy per cropped acre estimated with respect to diesel tubewell water cost was above Rs. 200 in one and substantially less than this in the second rotation of the rice zone. However, the per acre subsidy was above Rs. 150 in one and less less than this in the other rotation followed over a wide area of the wheat zone. The irrigation subsidy per acre as estimated from electric tubewell water cost was over Rs. 100 in the rice area and less than Rs. 100 in wheat area for the same crop rotations considered in the analysis. The subsidy estimated from crop output value for three out of the four rotations of both the zones fell between its estimates derived from diesel and electric tubewells irrigation cost. A relatively high increase in prices of potatoes and onion during the recent past has increased the tot value of rotations inclusive of these crops, although their water requiremen

Table 4: Comparison of Different Inputs Subsidies per Acre Under Important Crop Rotations.

Crop Rotations	Canal Irrigation			Fertilizer (a)	Seed	Plant Protection	
	Diesel Well	Electric Well	Tax of water contribution			Aerial spray	Ground spray
	------Rs. -----						
Rice Zone							
Rice-Wheat-Fallow-Maize-Sugarcane	214	126	142	77	8	24	13
Rice-Wheat-Potatoes-Onion-Maize	172	101	305	85	6		
Wheat-Zone							
Wheat-Cotton-Sugarcane-Maize	163	94	130	81	8		
Wheat-Oilseeds-Cotton-Maize (Fodder)-Sugarcane	139	80	113	81	8		

Source: Columns 2-4 derived from tables 2 and 3. Column 5 developed from unpublished data in the Planning Division. The remaining columns were developed from Pakistan Economics Survey, 1976-77, 25-27 pp.

Note: (a) Recommended rates per acre in pounds of nitrogen for Mexi-Pak wheat, rice, sugarcane, cotton, maize, potatoes, and onion are 125, 90, 175, 75, 90, 90, and 60. The rates of phosphorons for these crops are, 75, 75, 75,50, 75,125 and 50 respectively.

and maturity period are not especially high. They constituted a superior alternative for low market value crops under the prevalent conditions of climate and water availability in the country.

As an incentive to raise farm productivity, subsidy has been provided in several inputs in the form of reduced sale prices. The canal irrigation appears to be subsidized through an analogous mechanizms of under-pricing it. To realize its relative importance, the irrigation subsidy has been compared with the subsidies involved in fertilizer, improved seeds and pesticides for respective crop rotations. The subsidies in fertilizer and seeds have been determined on the basis of recommended rates of their application for the crops included in different rotations. The subsidy in pesticides has, on the other hand, been determined from the government estimates of cost involved in aerial as well as ground spray of cropped acreage during 1976/77. Aerial spray under government operations is carried out entirely free of cost whereas the material sold to the farmers for ground spray is subsidized at the rate of 50 per cent (9). By comparison, the implicit subsidy involved in canal irrgation, far exceeds as depicted in table 4, any other farm input subsidy in most crop combinatio The canal irrigation subsidy in rice zone crop rotation is 2 to 3 times as large as in chemical fertilizer. The difference in the subsidies associated with these two inputs reduced considerably for wheat zone crops. In fact, t size of input subsidies depends on the level of their application in any cro When output prices are not vulnerable to decline beyond a certain fixed leve high value crops, which are input intensive, appropriate the maximum subsidy on use of recommended levels of irrigation water, fertilizer, etc. The marg of the subsidy has gradually been curtailed by increasing sale prices when t use level especially of newly introducted inputs increased to a desirable e The chemical fertilizer is the case in point. Water rates as a charge for irrigation water supply have periodically been raised but in no systematic

relationship with water requirements or with increases in farm prices and income. The amount of implicit subsidy continued to grow owing to a relatively higher rate of increase in both farm prices and irrigation expenses than in water rates. Water rates were increased from Rs. 4.29 per acre in 1933, to Rs. 11.30 in 1965 and to Rs. 16.48 in 1969, the last revision, to irrigate crops of wheat, rice, sugarcane, cotton, oilseeds and fodder. During 1933-34, Water rates accounted for 30 per cent of net farm income (13). However, they consitituted only about 5.8 per cent when the net income from the above set of crops including onion as derived by the Planning Division, in 1975-76 was considered (8). During 1964-67, the Soil Survey Organization assumed Rs. 5 per foot in Kharif and Rs. 10 in rabi as the canal irrigation cost derived from only running and replacement expenditure (1). These rates, which are exclusive of interest and depreciation cost of capital outlay of the canal network, will increase considerably if these are worked with current expenditure. For example , the adjustment of the above estimates for the general rise in prices from 1966 to 1976 raises the cost per acre foot of canal water to Rs. 13.35 in Kharif and to Rs. 28.70 in rabi. The level of canal irrigation per acre foot during rabi works out about the same as variable cost associated with pumping cost of water from electric tubewell.

In general, water rates for canal irrigation are not fixed on any scientific basis. There is a tacit agreement that water rates policy should not be concerned solely with the debt repayment of financial obligations of the canal system. As such, the fixation of water rates is governed by a mix of objectives like mobilization of savings, efficiency, growth of farm income, food production, stabilization of grower's income, etc. But the water rate policy has not clearly assigned any definite weights to these objectives. It is argued that water rates are fixed deliberately at a level lower than what

would be necessary to pay the debt obligations (16).

LIMITATIONS

The adjustment of field data on running expenses of tubewells may have introduced certain upward bias in pumping cost. Due to the non-availability of indices for the most recent year, the adjustment of the running expenses could not be made beyond December 1976. Thus, the adjusted data for running expenses for 1976 is combined with market price data for 1977.

The other limitations pertains to water rates policy which does not furnish any precise information of weigts that may be assigned to various objectives that govern the fixation of water rates. It is agreed that water rates are fixed deliberately low. To the extent water rates are underestimated, the canal subsidy measured with reference to tubewell water cost and crop output value is overestimated.

The Government estimates of net income of major crops used to work out its relationship with water rates relate to 1975-76. No more recent than these estimates were available.

Summary and Conclusion

The study sought to estimate the implicit subsidy appropriated in canal irrigation. The subsidy has been ascertained as a residual of the commercial value of surface irrigation assumed to be reflected by tubewell water cost minus water rates. The amount of the subsidy thus obtained was compared with its alternate estimation based on the contribution of irrigation in the market value of crops and water rates. Prior to the estimation of the subsidy with first approach the study examined the cost of production of water from a private diesel and electric tubewell. The total cost per hour was directly

and per acre foot inversely related with the discharge capacity of both types of tubewells. The total pumping cost per acre foot of water declined from Rs. 79 to Rs. 54 in diesel and from Rs. 57 to Rs. 29 in electric tubewells on the increase of discharge rate from 1 to 2 cusecs. However, the pumping cost of tubewells of all discharge levels was found to be Rs. 63.65 in diesel and Rs. 39.53 in electric set.

Thetubewell water cost approach revealed sugarcane and rice, heavy water delta crops, as highly subsidized at the rate of over Rs. 300 per acre and a little less than Rs. 200 when diesel and electric pumping cost was assumed to reflect the commercial value of canal irrigation. The minimum level of the subsidy was observed to be Rs. 45 and Rs. 25 in oilseeds with respect to diesel and electric water cost. However, the average amount of the subsidy per cropped acre of major crops was estimated as Rs. 163 and Rs. 112 when the value of surface supplies was expressed in diesel and electric tubewell water cost respectively.

The output value technique, on the other hand, showed that the irrigation of tobacco, potatoes and onion, which are medium water delta crops, was subsidized at a significantly higher rate than that of other crops. The irrigation of sugarcane and rice again involved a substantial amount of subsidy. The amount of subsidy per cropped acre varied from Rs. 500 to Rs. 50 with an average of Rs. 237.

The implicit subsidy appropriate in rice zone crop combinations was considerably in excess of that for wheat zone rotations. The average subsidy per cropped acre estimated from the cost of diesel tubewell was above Rs.200 in one and substantially less than this in the other rotation of the rice zone. In wheat zone, on the other

hand, the subsidy hovered around Rs. 150 per acre of the two rotations followed over a wide area. The per acre irrigation subsidy as estimated from electric tubewell delivery cost was over Rs. 150 and less than Rs.100 for the same crop rotations in the above zones respectively. The subsidry estimated from crop output value for three out of four rotations stood in between the estimates reflected by electric and diesel tubewell delivey cost in both the zones. By comparison, canal irrigation, under both the approaches, was found to be subsidized at a significantly higher rate than fertilizer, seeds and pesticides. The occurrence of large subsidy in canal irrigation is because the water rates do not vary in any consistent manner with the increase in water application or value of crops. The cost of surface irrigation and prices of farm products increased at a greater rate than water rates and therefore the size of the implicit subsidy grew constantly over the years.

The study seems to conclude on the basis of both the approaches of estimation that canal irrigation is subsidized at a high rate under the prevalent water rates. The existence of the large implicit subsidy provides a justification for certain upward revision of water rates of canal irrigated crops. A definite quantitative estimation of the increase cannot be derived in the presence of different estimates of irrigation subsidy, yielded by the two techniques, for the same crops and in the absence of explicit weights assigned to diverse objectives of the water rates policy. As such, there should be a simple method to verify the relevance of water rates from time to time. The most appropriate approach is to maintain water rates in a reasonable relationship with net income of each crop because it appears consistent with some of the objectives of the water rates policy. It may tentatively be suggested that water rates for wheat, maize and oilseeds that appropriate relatively

small amount of subsidy and yield small net income may be raised to 10 per cent of their net income. However, the water rates may be increased to 15 per cent of net income from sugarcane, rice, cotton potatoes and onion. If water rates determined as above from the government estimates of net income and related to electric tubewell water cost or taxable water contribution in output, the size of canal irrigation subsidy will be reduced considerably in the first set of crops but it will still be fairly high in the other category of crop. Despite the proposed increasedin water rate, the irrigation subsidy will still be higher than that receive in other inputs on per cropped acre basis under any crop rotation. The critical concept is the realistic estimation of net income of crops.

Appendix A-1

COST OF INSTALLATION OF A TUBEWELL WITH A DISCHARGE OF ONE CUSEC

Items	Number	Length or Dimensions	Price per Unit	Total Cost of Diesel Tubewell	Total Cost of Electric Tubewell	Remarks
1. Centrifugal Pump						
(a) Pump	1	(5"x5)	1177.00	1177.00	1177.00	
(b) Accassorics						
i) Bends	2	5" each	82.00	164.00	164.00	
ii) Flanges	4	5" each	31.00	124.00	123.00	
iii) Reflux Value	1	5"	236.00	236.00	236.00	
2. Diesel Engine						
(a) Engine	1	16 HP	825/HP	13200.00	-	
(b) Accessories						
i) Belt		40'	6.25/FT	250.00	-	If shaft is used then two pieces of less than 100 Ft.
ii) Bolts nuts	16	-	2.00	32.00	-	
iii) Pulley	1	33"	8.50/each	281.00	-	Three pulleys when shaft is used,(22"-30-48) on (22"-28-48") for 16-20 HP engine.
iv) Cooling pipe	1	50'	-	165.00		
v) Nuts and Bolts	58with engine	-	-	288.00	288.00	
vi) Silencer pipe	1	14'	-	130.00	-	
vii) Rubber sheets	5 to 6	-	-	30.00	-	
viii) Oil set	-	-	-	46.00	-	

Item	Number	Length or Dimensions	Price per Unit	Total Cost of Biesel Tubewell	Total Cost of Electric Tubewell	Remarks
3. Electric Motor a) Motor(1400 RPM)	1	15 HP	2644	-	3044.00	PECO and Siemen brands are nearly two times more expensive than common brands.
b) Accessories i) Switch(60 AMP)	1	For(10-18 HP)	140	-	140.00	Imported Material is more expensive.
ii) Switch(60 AMP)	1	" "	533	-	533.00	
iii) Electric Wiring	-	-	-	-	2000.00	
4. Plain Pipe (M.S)		(30',6",1/8")	30.00/Ft.	900.00	900.00	
5. Strainer Pipe		(90',6",1/8")	22.00/Ft.	1980.00		
6. Delivery Pipe(M.S)		(7',6",1/8")	30.00/Ft.	210.00	210.00	
7. Bail Plug		5"	-	275.00	275.00	
8. Boring Charger		(130',8")	10.50/Ft.	1350.00	1350.00	With Farmers own labor.
9. Engine House(Concrite)	-	(10'x10'x10')	-	2500.00	-	Low estimate
10. Masonary Work of Wite		(10',6' Radins)	-	3500.00	3500.00	Low estimate
11. Engine Fitting		-	-	593.00	-	
12. Motor Coupling		-	-	-	616.00	
13. Transportation of Boring Equipment	-		-	600.00	600.00	
14. Testing Water Samples	2	-	32.00	64.00	64.00	
15. Testing Sand Samples	2	-	32.00	64.00	64.00	
		Total Cost of Installation		28,159.00	15,284.00	
		Non-Capital Expenditure		2,671.00	2,694.00	
		Cost of Tubewell Machinery and Brick Work.i) Capital Equipment		19,488.00	9,090.00	
		ii) Masonary Work		6,000.00	3,050	

Note : If Brass filter then its cost (90',6",1/8") @ Rs. 85/Ft-7,650.

Appendix A-2

COST OF A TUBEWELL WITH 1.5 CUSEC

Items	Number	Length or Dimensions	Price per Unit	Total Cost of Diesel Tubewell	Total Cost of Electric Tubewell	Remarks
1. CENTRIFUGAL PUMP						
a) Pump	1	(6"x6")	1401.00	1401.00	1401.00	
b) Accessories						
i) Bends	2	6" each	92.00	184.00	184.00	
ii) Flanges	4	6" each	37.00	148.00	148.00	
iii) Reflux Value	1	6" each	263.00	263.00	263.00	
2. DIESEL ENGINE						
a) Engine	1	20HP	825/HP	16500.00	-	
b) Accessories						
i) Belt	1	50	6.25/HP	250.00	-	
ii) Belt nuts	16	-	2.00	32.00	-	
iii) Pulley	1	33"	8.50/inch	281.00	-	
iv) Cooling pipe	1	50'	-	165.00	-	
v) Nuts & Bolts	58 with Engine 52 or 25 with motor	-	-	288.00	288.00	
vi Silencer pipe	1	14	-	130.00	-	
vii) Rubber sheets	5-6	-	-	30.00	-	
viii) Oil set		-	-	46.00	-	

		(1)	(2)	(3)	(4)	(5)	(6)
3.	ELECTRIC MOTOR						
	a) Motor (1400 RPM)	1(1400 RPM)	20 HP	3452.00		3452.00	
	b) Accessories i) Switch (60 AMP)	1	20 HP	160.00	-	160.00	
	ii) Starter (MEM)	1	"	577	-		577.00
	iii) Electric wiring	-	-	-	-		2000.00
4.	PLAIN PIPE (M.S.)		(30', 6",1/8")	30.00/Ft.	900.00	900.00	
5.	STRAINER PIPE		(100',1/8 6")	22.00/Ft.	2,200.00	2,200.00	
6.	Delivery Pipe (M.S)		(?',6",1/8")	30.00	210.00	210.00	
7.	BAIL PLUG		6"	-	300.00	300.00	
8.	BORING CHARGES		140',8"	10.50/Ft.	1,470.00	1,470.00	
9.	ENGINE HOUSE (Concrete)		(10'x10'x10')	-	2,500.00	-	
10.	MASONARY WORK OF WELL		-	-	3,500.00	3,500.00	
11.	ENGINE FITTING		-	-	593.00	-	
12.	MOTOR COUPLING		-	-	-	616.00	
13.	TRANSPORTATION OF BORING EQUIPMENT		-	-	600.00	600.00	
14.	TESTING WATER SAMPLES				64.00	64.00	
15.	TESTING SAND SAMPLES				64.00	64.00	
16	TOTAL COST OF INSTALLATION				32,119.00	18,307.00	
	NON-CAPITAL EXPENDITURE				2,791.00	2,814.00	
	COST OF TUBEWELL MACHINERY AND BRICK WORK		i)Capital Equipment		23,328.00	12,083.00	
			ii)Masonary work		6,000.00	3,500.00	

Note: If Brass Fitter its cost @ 85.00 Ft for(100' 6" 1/8")=8.500.

Appendix A-3

COST OF INSTALLATION OF A TUBEWELL WITH A DISCHARGE OF ONE CUSEC

Item	Number	Length of Dimensions	Price per Unit	Total Cost Diesel Tubewell	Total Cost of Electrical Tubewell	Remarks
1. CENTRIFUGAL PUMP						
(a) Pump	1	7" x 6"	1637.00	1637.00	1637.00	
(b) Accessories						
i. Bends	2	7', 6"	108.00	216.00	216.00	
ii. Flanges	4	7", 3(6"0	46.00	184.00	184.00	
iii. Reflux Value	1	7"	290.00	290.00	290.00	
2. DIESEL ENGINE						
(a) ENGINE	1	24 HP	825.00	198.00	--	
(b) ACCESSORIES						
i. Belt	1 to 2	40'	6.25	250.00	--	If crank shaft is used then two pieces of less than 100 F
ii. Belt nuts	16	-	2.00	32.00	--	
iii. Pulley	1	36"	8.25	306.00	306.00	If crank shaft then three pulleys (22-30"-482) are needed.
3. ELECTRIC MOTOR						
(a) MOTOR (1400 RPM)	1	25 HP	-	-	4283.00	
(b)						
i. Switch (200 AMP)	1	For 20-25 HP	-	-	186.00	
ii. Starter (MEM)	1	" " "	-	-	657.00	
iii. Electric wiring-			-	-	2000.00	

Item	Number	Length of Dimensions	Price per Unit	Total Cost Diesel Tubewell	Total Cost Electrical T Tubewell	Remarks
4. PLAN PIPE (M.S)	-	45; 8", 1/8)"	45.00	2025.00	2025.00	
5. STRAINE-R PIPE (coir)	-	(120',8",3/18)"	40.00	4,800.00	4,800.00	
6. DELIVERY PIPE (M.S)	-	(10,8",1/8)"	45.00	450.00	450.00	
7. BAIL PLUG	-	8"	-	350.00	350.00	
8. BORING CHARGES	-	(180',10")	11.00	1980.00	1980.00	
9. ENGINE HOUSE (CONCRETE)	-	10'x10'x10)	-	3000.00	-	
10. MASONARY WORK OF WELL	-	10',7'redinds)	-	3,500.00	3500.00	
11. ENGINE FITTING	-			593.00	-	
12. MOTOR COUPLING	-	-	-	-	600.00	
13. TRANSPORTATION OF BORING EQUIPMENT	-	-	-	600.00	600.00	
14. TESTING WATER SAMPLES	2		32.00	64.00	64.00	
15. TESTING SAND SAMPLES	2		32.00	64.00	64.00	
	Total Cost of Installation			40,818.00	24,492.00	
	Non-capital expenditure			3,301.00	3,308.00	
	Cost of Tubewell i.		Capital Equipment	31,017.00	17,684.00	
	ii.		Masonary work	6,500.00	3,500.00	

Note: If Brass Filter (120,8".1/8") @ Rs. 135.00/Ft = 16,200

Appendix B

Operational Characteristics of Different Size Private Tubewells in Punjab

Discharge	Area	Diesel Well						Electric Well					
		Sample Tube-wells	Annual Operation Days.	Ave-age Ope-ation Hou-rs.	Ann-ual Ope-ration Hou-rs.	Ope-rat-ion-Cost	Adjus-ted[a] Oper-tion-al Cost	Sam-ple Tube wells	Annu-ual Oper-ation Days	Aver-age Dai-ly Ope-rat-ion Hours.	Annual Opera-tion Hours.	Opera-tional Cost.	Adjusted Operational Cost.
1.0 Cusec	Lahore Division	8	245.0	13.0	3,185	7,069	8,827	22	214.3	9.1	1,950	5,222	6,483
	Sargodha "	6	224.7	10.5	2,359	11,825	14,804	-	-	-	-	-	-
	Multan "	10	256.5	12.5	3,206	14,427	18,067	14	296.7	10.7	3,175	8,373	10,384
	Overall	24	244.3	12.1	2,956	11,091	13,882	36	246.4	9.7	2,390	6,847	8,496
1.5 Cusec	Lahore Division	26	260.0	8.7	2,262	9,230	10,090	11	270.0	9.8	2,659	6,168	7,676.
	Sargodha "	19	226.0	8.4	1,899	7,976	10,246	12	240.8	9.0	2,179	9,097	10,391
	Multan "	21	212.0	11.9	2,533	12,525	15,583	26	230.9	10.5	2,322	8,219	10,298.
	Overall "	56	227.0	9.6	2,179	10,173	11,386	49	242.0	9.6	2,335	8,116	10,092.
2.0 Cusec	Lahore Division	19	232.0	13.1	3,039	12,088	15,155	6	283.4	11.8	3,340	8,758	10,891
	Sargodha "	8	198.0	10.1	2,010	13,689	17,125	6	256.6	14.3	3,669	9,463	11,756
	Multan "	22	243.6	11.0	2,680	13,371	16,747	23	293.9	10.3	3,027	8,304	10,238
	Overall "	49	231.2	11.8	2,728	12,838	16,084	35	285.7	11.2	3,200	8,389	10,433

Source: Appendices 4 to 9

a : Figures in columns 7 to 13 represent operational cost for the final quarter of 1974 during which the field survey was conducted. Thses figures have been adjusted to account for the rise in prices of different components of variable cost, with reference to relevant price indexed for December 1974 and December 1976 for which the indices are available to be able to combine them with capital cost of tubewell machinery as certained with a market survey during the latter month. Diesel, electricity and the rest costs of operations were adjusted with fuel and lubricants, electricity and general wholesale price indexes respectively (Statistical Bulletins , Nov-Dec. 1975 and Sept and Dec 1976, pp.85 and 90 respectively).

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