APPENDIX – III

UNIT COST OF GROUND WATER

****

III.1 GENERAL

Another variable in the objective function is unit cost of ground water, which is discussed here. The unit cost of ground water consists of

(A) Annual capital cost per ha.m application of water

(B) Operation, maintenance and repair cost per ha.m application of ground water

Total O.M.R. cost / ha
= Cost 1 + Cost 2

Cost1 = Depreciation + Repairs/Maintenance + Interest on capital investment + Operation cost

Cost 2 = Electricity charges

III.2 METHODOLOGY

Cost A

Annual Capital Cost

Capital investment required for a shallow tube well in year 1999
= Rs. 50,000

Capital recovery factor (C.R.F.)
= (A / P, i %, n)

Where,

A = Annuity (amount which has to be paid every year to repay the investment)

P = Present Value

i = Interest rate

n = Period of investment (economic life of shallow tube well)

Considering prevailing interest rate (i%) as 12% and economic life of tube well (n) as 20 years,

$$C.R.F. = \frac{i(i+1)^n}{(i+1)^n - 1}$$

$$= \frac{0.12\ (0.12+1)^{20}}{(0.12+1)^{20} - 1}$$

$$= 0.1338787$$

Annual capital cost = C.R.F. x Total capital cost

= 0.1338787 x 50,000

= Rs. 6,693.93

Area Irrigated by a Shallow Tube Well in a Year

Average discharge of a shallow tube well/open well = 210 liter per minute

Assuming average working hours of 11 per day and the pump operates for 190 days in a year

The average area irrigated by one shallow tubewell for unit depth,

$$= \frac{210 \times 60 \times 10^{-3} \times 11 \times 190 \times 10^{-4}}{1}$$

= 2.6334 ha

Annual capital cost / ha = 6,693.93 / 2.6334

= 2,541.94 Rs./ha

Considering unit depth of water application,

Annual capital cost = 2,541.94 Rs./ha.m

Cost B

Operation, Maintenance and Repairs (O.M.R.) Cost

Cost 1

Taking depreciation as 10% of capital investment per year

Depreciation Cost = 0.10 x 50,000

= Rs. 5,000

Assuming maintenance repair and charges as 3% of capital investment

Maintenance and repair cost = 0.03 x 50,000

= Rs. 1,500

Considering 12% interest on capital investment per year

Interest =0.12 x 50,000

= Rs.6,000

Operational charges per year

Considering salary of pump operator Rs.1,500 per month

Operational charges = 1,500 x 12

= Rs. 18,000

Cost 1= 5,000 + 1,500 + 6,000 + 18,000

= Rs. 30,500

$$\text{Cost 1/ha} = \frac{30{,}500}{2.6334}$$

= 11,581.98 Rs./ha

Considering unit depth of water application.

Cost 1= 11,581.98 Rs./ha.m

Cost 2

Working out power consumption

$$\text{Power of the pump set, } P = \frac{\gamma \times Q \times H}{75}$$

where,

P = Power of the pump set, H.P.

γ = Unit weight of water, kg / m^3

= 1000 kg / m^3

Q = Average discharge of the tube well, m^3/s

$$= \frac{210 \text{ l.p.m.}}{1000} \times \frac{1}{60}$$

= 0.0035 m^3/s

H = Total head acting on pump, m

Total head for different seasons are given in Table III-1.

Power of the pump set

$$P = \frac{1000 \times 0.0035 \times H}{75} \text{ H.P.}$$

$$= 0.046667 \times H, \text{ H.P.}$$

Now, considering 50% overall efficiency of the pump and using the relation,

1 H.P. = 0.75 kW

$$P = \frac{0.046667 \times 0.75 \times H}{0.5}$$

$$P = 0.07 \times H, \text{ kW}$$

Table III-1 : Total Head Acting on the Pump

Sr. No.	Head	Kharif m	Rabi m	Hot weather m
1	Depth of the static water level in the well	6.0	9.0	11.0
2	Drawdown during pumping	0.5	1.5	4.0
3	Delivery head from tube well site to the highest portions of irrigation land	3.0	3.0	3.0
4	Friction and other minor losses	2.0	2.0	2.0
	Total Head acting on pump	11.5	15.5	20.0

For Kharif,

H = 11.5 m

P = 0.07 x 11.5

= 0.805 kW

For Rabi,

H = 15.5 m

P = 0.07 x 15.5

= 1.085 kW

For Hot weather,

H = 20.0 m

P = 0.07 x 20.0

= 1.4 kW

Time Required to Extract Ground Water, ha.m

Average discharge of shallow tube wells or open well

= 210 lpm

= 0.21 m^3 / min

= 12.6 m^3 / h

The time required extracting 1 ha.m ground water

= 10,000 / 12.6

= 793.65 h

Total Units, kW h of Electricity Consumed for Extracting 1 ha.m of the Ground Water

No. of units consumed = Power of pump set (kW) x Time (h)

For Kharif,

No. of units consumed = 0.805 x 793.65

= 638.89 kW h

For Rabi,

No. of units consumed = 1.085 x 793.65

= 861.11 kW h

For Hot Weather,

No. of units consumed = 1.4 x 793.65

= 1,111.11 kW h

Table III-2: Cost of Power

Year	Cost of power Rs./Unit
1999-2000	3.0

Source: Gujarat Electricity Board, Baroda.

N.B.: Cost of power includes capital cost of power generation, distribution and Staff charges etc. worked out for a unit of power.

Table III – 3 : Electricity Charge Per ha.m Per Season

Year		1999-2000
Rs. / Unit		3.0
Season	No. of units	Cost II
Kharif	638.89	1,916.67
Rabi	861.11	2,583.33
Hot Weather	1,111.11	3,333.33

Total Cost of ground water per ha.m per season is given in Table III-4.

Table III-4 : Unit Cost of Ground Water for the Year 1999-2000

Season	Annual Capital cost Rs./ha.m/season	O.M.R. cost Rs./ha.m/season	Electricity charges Rs./ha.m/season	Unit cost Rs./ha.m/season
(a)	(b)	(c)	(d)	(e = a+b+c+d)
Kharif	2,541.94	11,581.98	1,916.67	16,040.59
Rabi	2,541.94	11,581.98	2,583.33	16,707.25
Hot Weather	2,541.94	11,581.98	3,333.33	17,457.25