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

\[ = \text{Cost 1} + \text{Cost 2} \]

Cost 1 = 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

\[ = \text{Rs. 50,000} \]

Capital recovery factor (C.R.F.)

\[ = (A / P, i \%, n) \]

Where,

\[ A = \text{Annuity (amount which has to be paid every year to repay the investment)} \]

\[ P = \text{Present Value} \]

\[ i = \text{Interest rate} \]

\[ n = \text{Period of investment (economic life of shallow tube well)} \]

Considering prevailing interest rate (i%) as 12% and economic life of tube well (n) as 20 years,
\[
\text{C.R.F.} = \frac{i (i + 1)^n}{(i + 1)^n - 1} \cdot \frac{0.12 (0.12+1)^{20}}{(0.12+1)^{20} - 1} = 0.1338787
\]

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,
\[
\frac{210 \times 60 \times 10^{-3} \times 11 \times 190 \times 10^{-4}}{1} = 2.6334 \text{ ha}
\]
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

Cost 1/ha = ----------------
    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.
\( \gamma \) = Unit weight of water, kg / m\(^3\)
    = 1000 kg / m\(^3\)
\( Q \) = Average discharge of the tube well, m\(^3\)/s
    = \( \frac{210 \text{ l.p.m.}}{1000 \text{ l.m} \times 60} \)
    = 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

\[ P = \frac{1000 \times 0.0035 \times H}{75} = 0.046667 \times H, \text{ H.P.} \]

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

\[ 1 \text{ H.P.} = 0.75 \text{ kW} \]

\[ P = \frac{0.046667 \times 0.75 \times H}{0.5} = 0.07 \times H, \text{ kW} \]

### Table III-1: Total Head Acting on the Pump

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

For Kharif,

\[ H = 11.5 \text{ m} \]

\[ P = 0.07 \times 11.5 \]

\[ = 0.805 \text{ kW} \]

For Rabi,

\[ H = 15.5 \text{ m} \]

\[ P = 0.07 \times 15.5 \]

\[ = 1.085 \text{ kW} \]

For Hot weather,

\[ H = 20.0 \text{ m} \]

\[ P = 0.07 \times 20.0 \]

\[ = 1.4 \text{ kW} \]
Time Required to Extract Ground Water, ha.m

Average discharge of shallow tube wells or open well

\[
\text{time required extracting 1 ha.m ground water} = \frac{10,000}{12.6} = 793.65 \text{ h}
\]

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) \times \text{Time (h)}

For Kharif,

No. of units consumed = 0.805 \times 793.65

= 638.89 kW h

For Rabi,

No. of units consumed = 1.085 \times 793.65

= 861.11 kW h

For Hot Weather,

No. of units consumed = 1.4 \times 793.65

= 1,111.11 kW h

Table III-2: Cost of Power

<table>
<thead>
<tr>
<th>Year</th>
<th>Cost of power Rs./Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999-2000</td>
<td>3.0</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Season</th>
<th>No. of units</th>
<th>Cost II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>638.89</td>
<td>1,916.67</td>
</tr>
<tr>
<td>Rabi</td>
<td>861.11</td>
<td>2,583.33</td>
</tr>
<tr>
<td>Hot Weather</td>
<td>1,111.11</td>
<td>3,333.33</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Season</th>
<th>Annual Capital cost</th>
<th>O.M.R. cost</th>
<th>Electricity charges</th>
<th>Unit cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rs./ha.m/season</td>
<td>Rs./ha.m/season</td>
<td>Rs./ha.m/season</td>
<td>Rs./ha.m/season</td>
</tr>
<tr>
<td>Kharif</td>
<td>2,541.94</td>
<td>11,581.98</td>
<td>1,916.67</td>
<td>16,040.59</td>
</tr>
<tr>
<td>Rabi</td>
<td>2,541.94</td>
<td>11,581.98</td>
<td>2,583.33</td>
<td>16,707.25</td>
</tr>
<tr>
<td>Hot Weather</td>
<td>2,541.94</td>
<td>11,581.98</td>
<td>3,333.33</td>
<td>17,457.25</td>
</tr>
</tbody>
</table>