CHAPTER-3

RESEARCH METHODOLOGY
3.0. RESEARCH METHODOLOGY

3.1 Research Design and Data Base.

For the purpose of this study, the Lower Ganga Canal System was divided into six sub-canal/branch-canal systems. These sub-canals command areas were demarcated with the help of canal officials with the blocks as the primary unit. For each sub-canal system, two villages and twenty farmers were taken assuming uniform cropping pattern in the whole command area of the sub-canal system. Input-output coefficients were developed for each such uniform cropping pattern area.

Different normative plans worked out are given as under:

<table>
<thead>
<tr>
<th>Normative Plan</th>
<th>Resource Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Existing supply of canal water plus tubewell water.</td>
</tr>
<tr>
<td>B to D</td>
<td>Existing supply of tube-well water plus 10, 20 and 30 per cent increase in canal water.</td>
</tr>
<tr>
<td>E</td>
<td>Ten per cent increase in tube-well water plus 10 per cent increase in canal water.</td>
</tr>
<tr>
<td>F</td>
<td>Twenty per cent increase in tube-well water plus 20 per cent increase in canal water.</td>
</tr>
<tr>
<td>G</td>
<td>Thirty per cent increase in tube-well water plus thirty percent increase in canal water.</td>
</tr>
<tr>
<td>H to J</td>
<td>Existing supply as canal water plus 10, 20 and 30 per cent increase in tube-well water</td>
</tr>
<tr>
<td>K</td>
<td>Existing supply of canal water only.</td>
</tr>
<tr>
<td>L, M, N</td>
<td>10, 20 and 30 per cent increase in canal water only.</td>
</tr>
</tbody>
</table>
Thus, in all fourteen solutions were obtained for each canal system (zone).

An attempt was also made to obtain a global overall solution combining all these six canal zones. This global solution which was obtained by assuming the canal and tube-well water supplies at their existing levels yielded optimum water allocation among different canal zones and different months of the year.

For the purpose of studying the economics of minor irrigation from different sources, a sub-division was selected purposively which has the maximum intensity of state tube-wells. Four villages in this region were selected on the basis of selection being the simultaneous availability of different sources of irrigation viz., canal, private tube-wells and state tube-wells. This purposive selection was necessitated by the need to compare the economics of irrigation from different sources which could best be done by selecting villages where these sources coexisted. In all, 60 farmers were selected randomly from these villages. Costs and returns were worked out exclusively source-wise. Productivity of water from different sources was also examined and compared with respective costs in order to examine the reationality of water use.

Secondary data regarding discharge and capacities of different canals were collected from the office of the Chief Engineer, Irrigation (Canal), Lucknow. Block-wise data of electric motors and diesel engines falling under these canal zones were collected from the office of the U.P. State Tubewell Corporation, Lucknow, irrigated area under different canal
command zones was collected from their respective local irrigation offices.

Secondary data for state tube-wells were collected from the office of the U.P. State Tubewell Corporation, Lucknow. Data regarding the input-output coefficients used in the study has been taken from the scheme “Economic Potential of Grain Production in U.P.” and “Cost of Cultivation of Principal Crops in U.P.”, conducted by the Department of Agricultural Economics, Agricultural University, Kanpur. However, primary data in respect of minor irrigation for this study were collected personally on pre-tested schedules by survey methods from the selected sub-division.

3.2. Limitation of Data Used.

(i) The period of reference for the purposes of this study has been taken as only one agricultural year. Perhaps, generalisations made on the basis of data for a single year and the conclusions derived could be questioned on the grounds that they are not representative. However, in order to meet this limitation, care has been taken to choose a ‘normal’ agricultural year-characterised by adequate rainfall and not a drought year. This factor is very relevant for a study primarily related to the agricultural sector.

(ii) Owing to the lack of manpower, time and resources, it has not been possible to undertake a follow up study. Cross-sectional data has been relied upon instead. Wherever possible some figures from the benchmark survey have been referred to.

(iii) As the data for a full agricultural year is collected in one or two sittings, memory bias of the respondents was to overestimate the
expenditure and under-estimate the income and production.

An attempt has been made to overcome these limitations to a great extent by cross checking the village-level data with officials from the Department of Irrigation (check-list), village pradhans, etc. and through personal observations.

3.3. The Model and the Tools of Analysis.

Normative cropping pattern and thus the normative water allocation was worked out by applying the profit-maximising technique of Linear programming. Model used for the study was:

Maximize = \( \sum P_iX_i - \sum C_jW_j - \sum e_jW_j - \sum d_jW_j \)

Subject to: \( \sum \frac{W_jR_iA_i}{N} = \frac{\text{Total water charges for all crops}}{\text{Total water used for all crops}} \)

\[ \sum_{j=1}^{n_i} a_{ij}x_j \leq b_i \quad i = 1, \ldots, m_i \]

Water constraints for canal, electric motors and diesel engines:

\[ \sum_{j=1}^{n_i} a_{ij}x_j \leq b_{i+12} + b_{i+24} \]

i = m_i + 1, .................., m_i + 12

non-negativity constraints:

\[ x_j \geq 0 \quad w_j \geq 0 \]

where,

Z = Gross Net Returns

\( P_j = \) per acre net returns from jth activity, including cost of irrigation
$C_j = \text{Cost per acre feet of water for canal}$

$e_j = \text{Cost per acre feet of water for EM}$

$d_j = \text{Cost per acre feet of water for DE}$

$W_j = \text{Level of water used in jth month}$

$a_{ij} = \text{Level of ith resource used by the per unit jth activity}$

$x_j = \text{Level of jth activity}$

$b_i = \text{Availability of ith resource}$

$j = 1 \ldots n_1 \text{ are for crop activities}$

$j = n_1 + 1 \ldots n_1 + 12 \text{ are for canal activities for twelve months}$

$j = n_1 + 13 \ldots n_1 + 24 \text{ are for electric motor activities for twelve months}$

$j = n_1 + 25 \ldots n_1 + 36 \text{ are for diesel engine activities for twelve months}$

To study the economics of minor irrigation Cobb-Douglas and Linear Programming Functions were fitted for different crops. The specification of these functions were as under:

Cobb-Douglas function:

$$Y = AX_1^{B_1}X_2^{B_2}X_3^{B_3}X_4^{B_4}X_5^{B_5}e^U$$

and Linear Function:

$$Y = A + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + U$$

Where,

$Y = \text{Value output of the crop}$

$X_1 = \text{Area under the crop}$
\[ X_2 = \text{Cost of seed cum fertilizer} \]
\[ X_3 = \text{Cost of mechanical and bullock power} \]
\[ X_4 = \text{Number of irrigations} \]
\[ X_5 = \text{Human labour in man-hours} \]
\[ U = \text{Error term} \]

Bet fit was judged on the basis of \( R^2 \) value etc. Economics for private diesel engines, electric motors and state tube-wells were also worked out on the basis of per unit investment and cost per unit of water from these sources.

3.4. Specifications of Variables Used.

3.4.1. Land

Command areas as classified by the Irrigation Department for each canal system was taken as the land available for Kharif as well as rabi season.

3.4.2. Maxima and Minima Constraints.

Maxima constraints was put on the profitable but risky crops due to the marketing and management constrains. These crops were sugarcane, Urd in Kharif and oliseeds, vegetables in the rabi season. Minima was imposed on less remunerative crops like maize, urd due to the necessary family and farm requirements. These were calculated on per farm basis which were then inflated for the command area.
3.4.3. Fixed Capacity.

Fodder for both the seasons was treated as the fixed activity since optimisation was done only for the crop activities other than dairying.

3.4.4. Water Constraints.

Net availability of canal water was taken as the fifty-five per cent of the discharge in different months, i.e. forty-five per cent was assumed to be lost. The transit losses in alluvial areas of U.P. as per estimates of International Commission on irrigation and Drainage (1967) are as follows:

(a) **Distribution of Water Losses**:

<table>
<thead>
<tr>
<th>Losses from canals &amp; branches</th>
<th>= 17% of head discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Losses from distributaries</td>
<td>= 08% of head discharge</td>
</tr>
<tr>
<td>Losses from water courses</td>
<td>= 20% of head discharge</td>
</tr>
<tr>
<td>Total</td>
<td>= 45% of head discharge</td>
</tr>
</tbody>
</table>

Net availability of water in acre-feet from electric motors was calculated on the basis of number of electric motors in the command area and on the assumption that an electric motor will work for 25 days a month and eight hours a day.

Net availability of water from diesel engines was calculated on the basis of number of diesel engines in the command area and the assumption that a diesel engine will work for 20 days a month and eight hours a day due to its higher wear and tear.
(b) Hiring and Transfer Charges.

Hiring activities per acre feet of water were introduced in the matrix for canal, electric motors and diesel engines. Hiring rate for canal water was worked out on the basis of field data on cropping pattern, water consumption by different crops and canal rates charged by the Irrigation Department, i.e.:

$$\tau \sum \frac{W_iR_iA_i}{N} = \frac{\text{Total water charges for all crops}}{\text{Total water used for all crops}}$$

\(\tau\) is average cost for per acre feet of water where,

- \(W_i\) is water consumed by \(i\)th crop in acre feet
- \(R_i\) is rate charged on per acre basis by Irrigation Department.
- \(A_i\) is area under \(i\)th crop in that command area in acres.
- \(N\) is total number of crops sown in that area.

Similarly, hiring rate per acre feet of water for electric motors and diesel engines was calculated at the U.P. level, i.e., same for all the canal command areas.