Chapter- III

MATERIALS AND METHODS

The precision of the research findings depends upon how aptly and rationally the sampling procedure is adopted. This chapter delineates the methodology adopted to draw results under each objective defined in the first chapter. This chapter deals with the selection of the study area, the sample and the analytical framework. The chapter has been broadly divided into four sections and discussed.

3.1 Selection of the Study Area
3.2 Sampling Plan
3.3 The Data
3.4 Analytical Tools

3.1 SELECTION OF THE STUDY AREA

Mandi district of Himachal Pradesh was purposively selected for the present study (Fig. 3.1) which is predominantly an agriculture tract where majority of the people (74 per cent as against 63 per cent in Himachal Pradesh) depends on agriculture for their livelihood. Mandi district constitutes 15.88 per cent of the net cultivated area of Himachal Pradesh (Anonymous, 2004). Maize, paddy and wheat are the main crops of Mandi district but glaring disparities have been observed in production pattern in different sub-ecological regions of this district. Based on agro-climatic condition, Mandi district has been divided into three distinct regions (i) Foot hills comprising Balh, Sandhol and Baldwara regions (ii) Mid hills comprising Nagwain, Gohar, Riwalsar area, part of Jogindernagar and Karsog tehsil (iii) High hills compring the area of Janjehly, Gadagosain, Chuhar Valley, Seri, Kothi and Pangna (District Census, 1981).
3.2 SAMPLING PLAN

Stratified two stage random sampling technique was adopted to select the sample for the study considering sub-ecological regions as strata. Selection of villages was done in first stage and in second stage ultimate households were selected.

3.2.1 Selection of Villages

In the first stage of sampling, a complete list of villages in each sub-ecological region was taken from the respective block offices and out of this 5 villages were selected randomly from each sub-ecological region.

3.2.2 Selection of Sample Households

In the second and final stage of the sampling, a complete list of all the farm households in each of the selected villages was compiled. Ultimately, keeping in view the time and financial constraints 50 farm households from each sub-ecological region were proportionally allocated in the selected villages. Thus in all, a sample of 150 farm households of different sub-ecological regions was selected (Table 3.1). The schematic sampling plan has been shown through Fig. 3.2

3.3 THE DATA

Both primary and secondary data were collected to meet out the various objectives of the study.

3.3.1 Survey Schedule

Survey schedule was designed for the collection of detailed primary data from the respondents in the study area after its pretesting

3.3.2 Primary Data
Both cross section and time series data for the present study were collected through personal visit to the households. Commensurate with the set objectives of the study, cross sectional data collected during 2002-03 included the information on following aspects:

**Family background and farm infrastructure** such as caste, age, family size/structure, education, occupation, land inventory, farm implements and machinery inventory, livestock inventory, etc. **Resource utilization and production systems** like cropping pattern, input-use pattern, human labour, bullock labour, crop yields, livestock production, farm prices etc. **Problems and constraints** comprised production, financial, marketing, institutional

### Table 3.1: List of selected villages and distribution of sample households

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of village</th>
<th>Name of block</th>
<th>Number of selected farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td><strong>Low Hills</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Harwani</td>
<td>Sundernagar</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Chhatru</td>
<td>Sundernagar</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>Maher</td>
<td>Sadar</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>Nagwain</td>
<td>Sadar</td>
<td>8</td>
</tr>
<tr>
<td>5</td>
<td>Basadhar</td>
<td>Sadar</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>50</strong></td>
</tr>
<tr>
<td>II</td>
<td><strong>Mid Hills</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Kohru</td>
<td>Gohar</td>
<td>11</td>
</tr>
<tr>
<td>2</td>
<td>Tadhar</td>
<td>Gohar</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>Badehar</td>
<td>Chauntra</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Tharu</td>
<td>Chauntra</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Madlog</td>
<td>Riwalsar</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td></td>
<td><strong>50</strong></td>
</tr>
<tr>
<td>III</td>
<td><strong>High Hills</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Neeru</td>
<td>Thunag</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Thata</td>
<td>Thunag</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Graman</td>
<td>Drang</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Swar</td>
<td>Drang</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>Silh Budhwani</td>
<td>Drang</td>
<td>8</td>
</tr>
<tr>
<td>---</td>
<td>---------------</td>
<td>-------</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td><strong>Sub-total</strong></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td>150</td>
</tr>
</tbody>
</table>
and environmental constraints faced by the respondents. Time series data (1998-99 to 2002-03) were collected on area, production and prices of different crops and number and production of livestock from households.

3.3.3 Secondary Data

The secondary data on geographical area, population, sex ratio, population density of Mandi district and Himachal Pradesh were drawn from various published and unpublished documents of government offices.

3.4 ANALYTICAL FRAMEWORK

An attempt has been made to achieve the objectives of the present study by simple tabular analysis and also by using various statistical and mathematical tools.

3.4.1 Tabular Methods

This technique was employed to study the family structure, demographic features, land use pattern, cropping pattern, input use pattern and livestock production. The existing level of farm income and employment within agriculture and problems faced by the farmers of different sub-ecological regions were also analyzed through tabular analysis.

Cost concepts:

The different costs have been computed as follow (Dhondyal, 1982):

Cost $A_1 =$ It includes the following items (in Rs):

- Value of seed (owned and purchased)
- Value of manure (home produced and purchased)
- Value of fertilizers
- Value of insecticides and pesticides
- Value of hired and own bullock labour
- Wages of hired human labour (permanent and casual)
- Value of irrigation charges
Depreciation on fixed capital

Interest on working capital

Cost A_2 = Cost A_1 + rent paid for leased-in land

Cost B_1 = Cost A_1 + imputed interest on owned fixed capital (excluding land)

Cost B_2 = Cost B_1 + rental value of owned land

Cost C_1 = Cost B_1 + imputed value of family labour

Cost C_2 = Cost B_2 + imputed value of family labour

Cost D = Cost C_2 + 10 per cent of Cost C_2

3.4.2 Statistical Analysis

A. Corrected coefficient of variation

Corrected coefficient of variation was computed by using Cuddy Della Valle index (Singh and Byrlee, 1990). Since the simple coefficient of variation over estimates the level of instability in time series data characterized by long term trends, this index corrects the coefficient of variation.

\[ CV^* = CV \times (1-R^2)^{0.5} \]

\[ CV = \frac{SD}{Mean} \times 100 \]

Where

- \( CV \) = Coefficient of variation
- \( SD \) = Standard deviation
- \( R^2 \) = Coefficients of determination

B. Input-output relationship

Cobb-Douglas type of production function was fitted to examine the input-output relationship in cereal crops. This function was found the best fit on the basis of statistical criteria (\( \overline{R^2} \)). The form of this model is as follows:
\[ Y = b_0 X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} e^u \]

The log linear form of this model is

\[ \ln Y = \ln b_0 + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 \]

where,

- \( Y \) = Yield of crop under consideration (q/ha)
- \( X_1 \) = Seed (Rs/ha)
- \( X_2 \) = Fertilizer (Rs/ha)
- \( X_3 \) = FYM (Rs/ha)
- \( X_4 \) = Human labour (Mandays/ha)
- \( X_5 \) = Bullock labour (Bullock pair days/ha)
- \( b_0 \) = Constant
- \( b_1, b_2, b_3, b_4 \) and \( b_5 \) are regression coefficients (elasticities)

The Timmer measure of technical efficiency

Timmer (1971) imposed a Cobb-Douglas type specification on the frontier and computed an output based measure of efficiency. The approach adopted was to specify a fixed parameter frontier amenable to the statistical analysis.

The general form of the production function is given as

\[ Y = f(X) e^u \text{ where } u \leq 0 \]

In estimating the frontier production function, Corrected Ordinary Least Squares (COLS) is chosen as the most convenient means. As given earlier, in the first step OLS is applied to fit the Cobb-Douglas production function to obtain the best unbiased estimates of regression (\( b_i \)) coefficients. The constant (intercept) estimate is then corrected by shifting the function until no residual is positive and one function is zero. It is done by adding the largest error term (\( e_j \)) of the fitted model to the intercept.
The Timmer measure of technical efficiency of a farm is the ratio of the actual output to the potential output given at the level of input use on i\(^{th}\) farm. Thus it indicates that how much extra output could be obtained if i\(^{th}\) farm to be on the frontier. Timmer measure of technical efficiency is given by:

\[
TE = \frac{Y \text{ (actual output)}}{Y^* \text{ (frontier output)}}
\]

where

\[
Y^* = \text{ The maximum obtainable output (frontier output) given the levels of the inputs}
\]

The efficiency achieved by the farmers was worked out as

High efficiency farmers: above \(\mu + \sigma\)

Medium efficiency farmers: between \(\mu + \sigma\) and \(\mu - \sigma\)

Low efficiency farmers: below \(\mu - \sigma\)

where \(\mu\) is the mean and \(\sigma\) is the standard deviation

The Kopp measure of technical efficiency

Kopp (1981) suggested a different measure of technical efficiency in which the actual level of input used is compared to the level which would be used if i\(^{th}\) farm were to be located on the frontier, given the actual output of i\(^{th}\) farm and given the same ratios of input usage.

Kopp’s measure is given by:

\[
TE_i = \frac{X_i^*}{X_i}
\]

Where, \(X_i^*\) is the frontier and \(X_i\) is the actual use of i\(^{th}\) input.

The frontier input use (\(X_i^*\)) is worked out as follows:

If, \(\text{Ln}Y = \alpha + b_1 \text{Ln}X_1 + b_2 \text{Ln}X_2 + b_3 \text{Ln}X_3 + b_4 \text{Ln}X_4 + b_5 \text{Ln}X_5\)

Here \(\alpha\) is the corrected intercept, that is, \(\alpha = [\text{estimated log } b_0 + \text{ largest value of error term (e_j)}]\)

Then \(b_1 \text{Ln}X_1 = \text{Ln}Y -\alpha - b_2 \text{Ln}X_2 - b_3 \text{Ln}X_3 - b_4 \text{Ln}X_4 - b_5 \text{Ln}X_5\)
Adding $b_2 \ln X_1 + b_3 \ln X_1 + b_4 \ln X_1 + b_5 \ln X_1$ both sides

$$b_1 \ln X_1 + b_2 \ln X_1 + b_3 \ln X_1 + b_4 \ln X_1 + b_5 \ln X_1 = \ln Y - \alpha - b_2 \ln X_2 - b_3 \ln X_3 - b_4 \ln X_4 - b_5 \ln X_5$$

$$+ b_2 \ln X_1 + b_3 \ln X_1 + b_4 \ln X_1 + b_5 \ln X_1$$

$$(b_1 + b_2 + b_3 + b_4 + b_5) \ln X_1 = \ln Y - \alpha - [b_2 \ln X_2 - b_2 \ln X_1] - [b_3 \ln X_3 - b_3 \ln X_1] - [b_4 \ln X_4 - b_4 \ln X_1] - [b_5 \ln X_5 - b_5 \ln X_1]$$

$$\sum_{i=1}^{5} b_i [\ln X_1] = \ln Y - \alpha - b_2 \ln R_2 - b_3 \ln R_3 - b_4 \ln R_4 - b_5 \ln R_5 / \sum_{i=1}^{5} b_i$$

OR

$$X_1^* = \text{Antilog} \left\{ [\ln Y - \alpha - b_2 \ln R_2 - b_3 \ln R_3 - b_4 \ln R_4 - b_5 \ln R_5] / \sum_{i=1}^{5} b_i \right\}$$

Where

$R_2 = X_2 / X_1$; $R_3 = X_3 / X_1$; $R_4 = X_4 / X_1$; $R_5 = X_5 / X_1$

In the similar manner $X_2^*$, $X_3^*$, $X_4^*$ and $X_5^*$ were computed

**C. Adjusted coefficient of multiple determination**

Adjusted $\overline{R}^2$ is worked out by:

$$\overline{R}^2 = 1 - (1 - R^2) \times \frac{N-1}{N-K}$$

The significance of $\overline{R}^2$ was tested with the help of $F$-test as under:

$$F = \frac{\overline{R}^2}{1 - \overline{R}^2} \times \frac{N-K}{K-1}$$

**D. Returns to scale**

The sum of elasticity coefficients ($\sum b_i$) indicate the returns to scale and the statistical test for the significant difference of the value of coefficient from unity is given as

$$F_{(1, N-K)} = [(\sum b_i - 1)^2 / 1] / [(\sum \text{var} b_i) / (N-K)]$$
where

\[ N = \text{Sample size} \]

\[ K = \text{Number of exogenous variables} \]

**3.4.3 Risk Efficient Farm Production Plans**

For formulation of the risk efficient farm production plans, synthetic farm situations representing the farming characteristics of the low, mid and high hills farm situations in the study area were evolved. In order to assess the range of maximum and minimum value of the objective function linear programming techniques was adopted. Minimum range \((\lambda_l)\) was estimated by imposing minimum restriction in area for meeting home consumption needs with existing resources while maximum range \((\lambda_m)\) was estimated by minimum restrictions and augmenting the supply of inputs through hiring, borrowing and purchasing facilities. The risk efficient farm plans were then developed using the Minimization of Total Absolute Deviation (MOTAD) Model (Hazzel, 1984).

**3.4.3.1 Model**

To employ the model it was assumed that farmers were risk averters so that their objective function was defined by the dual criteria of maximization of expected gross returns and minimizing the variations associated with expected gross returns. The present model worked on \(E-A\) (expected income with absolute mean deviation) criterion instead of \(E-V\) (expected income with given variability) criterion of quadratic programming. The criterion was defined as Minimization of Total Absolute Deviation in RFFR to their expected values. Four farm plans were developed by minimizing mean absolute deviations to each fixed (parametric) level of RFFR.

In this present study different levels of expected RFFR were fixed by parametric programming and attempt was made to minimize risk associated with each fixed level of RFFR. The set of farm plans so obtained is called \(E-A\) farm plans or risk efficient farm
production plans. Four risk efficient farm plans were developed at different level of farm income under two situations viz., without and with dairy activity for each sub-ecological region. These farm plans are as follows:

P₁: Risk efficient farm plan minimum ($\lambda_l$) level of income

P₂: Risk efficient farm plan for $\lambda_l + \partial$ level of income

P₃: Risk efficient farm plan for $\lambda_l + 2\, \partial$ level of income

P₄: Risk efficient farm plan for $\lambda_l + 3\, \partial$ level of income

Where

$$\partial = \frac{\text{Optimized income with augmented resources (}\lambda_m\text{)} - \text{Optimized income with restricted resources (}\lambda_l\text{)}}{3}$$

The model used is of the following form

**A. Objective Function**

$$\text{Minimize } Z = \sum_{h=1}^{s} (Y^{h+} + Y^{h-})$$

The model can be solved on conventional linear programming codes with the parametric option and provides the set of farm plans that are efficient for expected income and mean absolute deviation. Thus, the alternative formulation for the MOTAD model based on minimizing only the sum of the absolute value of the negative total gross margins ($Y^{h-}$) was used. Thus, the objective function becomes:

$$\text{Minimize } Z = \sum_{h=1}^{s} Y^{h-}$$

The sum of absolute value of deviations of the returns to be minimized such that following constraints are satisfied:
B. Linearity constraints

\[ \sum_{j=1}^{n} (C_{hj} - g_j) x_j + Y^h \geq 0 \quad \text{(for all h, h = 1, 2, \ldots, s)} \]

This constraint enables the model to be solved on conventional linear programming codes. It instructed that absolute deviations must be equal to or greater than zero over the years.

C. Parametric constraints

This constraint enabled the parameterization of income to the maximization of the risk.

\[ \sum_{j=1}^{n} f_j x_j = \lambda \]

\[ \lambda = \text{parameter to start from minimum prescribed income } (\lambda_l) \text{ to maximum } (\lambda_m) \text{ attainable income.} \]

D. Resource constraints

\[ \sum_{j=1}^{n} a_{ij} x_j \leq b_i \quad \text{(for all i, i = 1, 2, \ldots, m)} \]

\[ \sum_{j=1}^{n} a_{ij} x_j \geq b_i \]

Minima for maize, wheat, paddy and cross bred cow

E. Non negativity constraint

\[ x_j \text{ and } Y^h \geq 0 \]

(for all h, j)
The constraint ensured the non-negativity level of activities and the negative returns deviations which must be taken in absolute terms.

Where,

\[ Z = \text{Sum of the absolute values of deviations of the returns of various enterprises from their mean values.} \]

\[ Y_{h} = \text{Absolute values of the negative total returns deviation of various enterprises in the } h^{th} \text{ year from their mean (} h = 1, 2, \ldots, s) \]

\[ C_{hj} = \text{Returns of } j^{th} \text{ farm activity in the } h^{th} \text{ year} \]

\[ g_{j} = \text{Mean value of the returns of the } j^{th} \text{ farm activity.} \]

\[ x_{j} = \text{Level of } j^{th} \text{ farm activity} \]

\[ f_{j} = \text{The expected returns per ha of the } j^{th} \text{ activity} \]

\[ \lambda = \text{Parameter showing total RFFR from all the farm activities} \]

\[ a_{ij} = \text{Technical requirement of the } j^{th} \text{ activity for the } i^{th} \text{ resource.} \]

\[ b_{i} = \text{The constraint level of the } i^{th} \text{ resource} \]

\[ s = \text{Number of time-series observations} \]

\[ n = \text{Number of farm activities} \]

In this model provision was made for capital borrowing at the 10 per cent rate of interest and hiring-in of casual labour at the rate of Rs 70/day and draft power at Rs 175/day as prevalent in the study area.

The variations in the total RFFR were examined by calculating the coefficient of variation using the following relationships.

\[
\text{S.D.} = \sqrt{\frac{1}{s-1} \sum_{h=1}^{s} \left( \sum_{j=1}^{n} \left( \sum_{h=1}^{s} C_{hj} x_{j} - \sum_{j=1}^{n} g_{j} x_{j} \right)^{2} \right) / n - 1}
\]

\[
\text{Coefficient of variation} = \frac{\text{S.D.}}{\text{Expected RFFR}} \times 100
\]
where

\[ S.D. = \text{Standard deviation} \]

\[ \text{RFFR} = \text{Returns to fixed farm resources} \]

### 3.4.3.2 Construction of matrix

Initial tableau of the model was formulated by using the cross sectional and time series data collected from the respondents. The existing technical coefficients for different farm activities were computed by averaging the cross sectional information collected from the farmers for each sub-ecological region.

The deviations of the returns from the mean were obtained from time series data.

### 3.4.3.3 Resource constraints

The different resource constraints used in the model have been discussed below:

**a) Land resource**

Land is the scarcest resource. On the basis of irrigation and season, average net cultivated area of farmers was divided into following four categories:

\[ A_{\text{kir}} = \text{Kharif irrigated land (ha)} \]

\[ A_{\text{kur}} = \text{Kharif unirrigated land (ha)} \]

\[ A_{\text{rir}} = \text{Rabi irrigated land (ha)} \]

\[ A_{\text{rur}} = \text{Rabi unirrigated land (ha)} \]

**b) Capital restriction**

The capital restriction viz. Kharif capital and rabi capital were constructed. Kharif and rabi capital were estimated by adding all the variable expenses incurred in crops on the following inputs:

- Purchased and own seed
- Hired human labour
- Hired and own bullock labour
Minor repair charges of farm implements and building  
Insecticides and pesticides  

**c) Human labour**

While estimating peak seasons family labour availability, male, female and children (adult female days and child days were converted into mandays by multiplying with 0.80 and 0.50, respectively) were taken into account (Saini, 1982). A period of eight hour of work was considered as one man day.

In the present study four human labour peak periods were identified during the year as given below:

<table>
<thead>
<tr>
<th>Peaks</th>
<th>Low hills</th>
<th>Mid hills</th>
<th>High hills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak-I</td>
<td>15th April to 30th April</td>
<td>1st May to 15th May</td>
<td>15th May to 31st May</td>
</tr>
<tr>
<td>Peak-II</td>
<td>1st July to 15th July</td>
<td>15th July to 30th July</td>
<td>1st Aug. to 15th Aug.</td>
</tr>
<tr>
<td>Peak-III</td>
<td>15th Sept. to 30th Sept.</td>
<td>1st Nov. to 15th Nov.</td>
<td>15th Nov. to 30th Nov.</td>
</tr>
<tr>
<td>Peak-IV</td>
<td>15th Oct. to 31th Oct.</td>
<td>1st Nov. to 15th Nov.</td>
<td>15th Nov. to 30th Nov.</td>
</tr>
</tbody>
</table>

Harvesting of rabi crops and sowing of kharif crops  
Transplanting of paddy and interculture of kharif crops  
Harvesting of kharif crops  
Sowing of rabi crops

Net availability of human labour during the peak periods was computed after providing the human labour required for fixed farm activities such as the raising of fodder for bullocks, attending to farm animals, repairs of farm buildings and attending to the socio religious functions besides the illness of worker and other unforeseen circumstances when labour could not be employed for farm works.
d) Bullock labour

The bullock labour resource availability on selected farms was estimated in terms of bullock pair days. Based on the bullock labour use pattern, the following peak periods were identified:

<table>
<thead>
<tr>
<th>Peaks</th>
<th>Low hills</th>
<th>Mid hills</th>
<th>High hills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak-I</td>
<td>22\textsuperscript{nd} April to 30\textsuperscript{th} April</td>
<td>8\textsuperscript{th} May to 15\textsuperscript{th} May</td>
<td>22\textsuperscript{nd} May to 31\textsuperscript{st} May</td>
</tr>
</tbody>
</table>

Ploughing of land for sowing of *kharif* crops

| Peak-IV | 23\textsuperscript{rd} Oct. to 31\textsuperscript{th} Oct. | 8\textsuperscript{th} Nov. to 15\textsuperscript{th} Nov. | 22\textsuperscript{nd} Nov. to 30\textsuperscript{th} Nov |

Ploughing of land for sowing of *rabi* crops

e) Fodder restriction

The availability of green and dry fodders on the farm (other than crop residues and fodder crops) was estimated on the basis of green fodder available from weed flora, field grasses, tree fodder from land. Similarly, dry fodder constituted the production of hay from pastures. The fodder availability was estimated after deducting the fodder requirement for bullocks that was considered as fixed activity in the model. The inter linkages were developed in the model to add up the green (fodder crops) and dry fodder (by products) available from different crops.

f) Fertilizers

One of the most limiting factors to select the product-mix was the chemical fertilizes. The low use of this resource in Himachal Pradesh was attributed to rainfed conditions and subsistence type of farming besides lack of resourcefulness of farmers. Urea *kharif*, urea *rabi*, IFFCO *kharif* and IFFCO *rabi* were the four fertilizer constraints.
g) Minimum area restriction for cereals

The growers invariably retain cereals for home consumption. Therefore, the restriction of minimum area for cereal was imposed. The minimum area of maize, wheat and paddy was estimated for consumption purpose according to the family size.

3.4.3.4 Selection of activities

The production processes (farm enterprises) used as activities in the model are given as follows

A) Crop activities

Crop activities included the following crops

<table>
<thead>
<tr>
<th>Kharif crops</th>
<th>Rabi crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize IR</td>
<td>Wheat IR</td>
</tr>
<tr>
<td>Maize UR</td>
<td>Wheat UR</td>
</tr>
<tr>
<td>Paddy IR</td>
<td>Barley UR</td>
</tr>
<tr>
<td>Paddy UR</td>
<td>Pea IR</td>
</tr>
<tr>
<td>Charry IR</td>
<td>Pea UR</td>
</tr>
<tr>
<td>Maize+mash UR</td>
<td>Garlic IR</td>
</tr>
<tr>
<td>Kodo UR</td>
<td>Garlic UR</td>
</tr>
<tr>
<td>Rajmash UR</td>
<td>Raddish IR</td>
</tr>
<tr>
<td>Mash UR</td>
<td>Mustard IR</td>
</tr>
<tr>
<td>Soybean UR</td>
<td>Mustard UR</td>
</tr>
<tr>
<td>Potato kharif UR</td>
<td>Barseem IR</td>
</tr>
<tr>
<td>Ginger UR</td>
<td></td>
</tr>
<tr>
<td>Tomato IR</td>
<td></td>
</tr>
<tr>
<td>Brinjal IR</td>
<td></td>
</tr>
</tbody>
</table>

IR = Irrigated

UR = Unirrigated
B) Livestock activities

The bullocks were considered as the fixed activity in the model. The livestock activity incorporated in the model is only cross-bred cow because of maximum livestock investment as well as highest net returns among cross-bred, local cow and buffalo in all the three regions.

C) Hiring, purchasing and borrowing activities

The following hiring, purchasing and borrowing activities were included in the matrix:

a) Hiring activities

Human labour hiring-in man days in period-I
Human labour hiring-in man days in period-II
Human labour hiring-in man days in period-III
Human labour hiring-in man days in period-IV
Bullock labour hiring-in bullock pair days in period-I
Bullock labour hiring-in bullock pair days in period-II

b) Purchasing activities

Urea _kharif_ purchasing in kilograms
Urea _rabi_ purchasing in kilograms
IFFCO _kharif_ purchasing in kilograms
IFFCO _rabi_ purchasing in kilograms

C) Borrowing activities

_Kharif_ borrowing in rupees
_Rabi_ borrowing in rupees

Capital transfer (_kharif_ to _rabi_) in rupees
The cost of hiring, purchasing and borrowing of the above activities was taken at the existing market rates.

The risk efficient farm plans were developed under two situations.

i) Crop enterprises

ii) Crop-dairy enterprises

The format of MOTAD employed for the formulation of risk efficient farm plans in low hills with crop and dairy enterprises has been appended in Appendix III.

3.4.4 Chi square test

The problems between different situations were tested for their differences in severity, using Chi-square test as under

$$\chi^2 = \sum_{i=1}^{n} \frac{(O-E)^2}{E}$$

Where,

O = observed value

E = expected value

n = number of problems and constraints