INCOME AND EMPLOYMENT GENERATION IN ALTERNATIVE FARMING SYSTEMS:
A STUDY OF CENTRAL BRAHMAPUTRA VALLEY ZONE OF ASSAM

IV

RESEARCH METHODOLOGY
CHAPTER IV

RESEARCH METHODOLOGY

The systematic planning and conduct of a piece of research programme demands an appropriate research methodology. This is a vital pre-requisite of any research study since it has a direct bearing on the relevance and validity of the research findings. In the realm of social science again, it is essential to use a standard method of research design, appropriate techniques of measurement of variables and rules or procedures for the testing of observations.

The methodological framework used for the present investigation has been discussed under the following subheads.

4.1 Locale of the Study

4.1.1 Brief description of the locale

4.2 Sampling Plan

4.2.1 Selection of district or zone

4.2.2 Selection of blocks

4.2.3 Selection of villages and the respondents
4.3 Analytical Techniques

4.3.1 Simple tabular analysis

4.3.2 Benefit-Cost ratio technique

4.3.3 Functional analysis

4.3.4 The programming model

4.1 Locale of the Study

4.1.1 Brief Description of the Locale

The Central Brahmaputra Valley Zone comprises mainly the undivided Nagaon district with an area of 5561 sq.km. The zone has extended from hills to plains creating number of physiographic variations. It has low hills, and hillocks extended to Karbi Anglong. Piedmont and high land areas in the eastern and southern sides, flood plain tract along the Brahmaputra delineated with recent flood and flood plains, Char and Chaparis as well as the beel areas. The undivided Nagaon district has been divided into Nagaon district and Marigaon district in 1990.
The zone is composed of both most recent immature soils (Entisol) in the Char areas and old mature soils (Alfisols) in piedmont highlands and hill areas, suitable for cultivation of all types of field and horticultural crops and fisheries.

The zone experiences hot and humid summer and dry and cool winter. Temperature varies from 8°C to 34.3°C with the humidity of 37 percent to 90 per cent. The average rainfall ranges from 1200 to 2000 mm and its distribution from one part to the other influences the cropping pattern.

The land use pattern of the zone shows that there is 4.02 lakh hectares under the net sown area and 1.83 lakh hectares are double cropped. Forest coverage is 17.50 per cent while 15.10 per cent of total geographical area is barren and put to non-agricultural use (Bhowmic et al., 1999).

The zone has diversification of horticultural crops including tea and forest. Homestead gardens are more prominent. The fruits grown are mainly banana, coconut, arecanut, jack fruits, mango, betel and papaya while common vegetables are brinjal, tomato,
potato, cabbage, beans, carrot, lady’s finger etc. and other leafy vegetables. Cultivation of spices and condiments are widely done. The common crops are rice, jute, pulses, oilseeds, wheat, vegetables and sugarcane.

4.2 Sampling Plan

A multi-stage random sampling technique was adopted for selection of districts (2), blocks (3), villages (15) and respondents (225) from the study area of Assam. The details of sampling plan in the study have been elaborated as follows:

4.2.1 Selection of the Districts or Zone

The present study was carried out in the purposively selected Central Brahmaputra Valley Zone (comprises only two districts) out of the six agro-climatic zones of Assam. The fact supported the purposive selection of above zone was:

i) This selected zone of Assam is predominantly agriculture oriented and the agricultural scenario of this
zone reflects the over-all scenario of agriculture in Assam. Further, the farmers are adopting different farming systems in their farm business in this zone.

ii) The other reasons behind the selection of the zone in question were:

a) There had been no in-depth study on diversification so far for increasing farm income and employment in this zone.

b) The existence of relatively better communication facility for survey and investigator's familiarity with the area, local dialects and the resources.

c) Easy accessibility to Regional Agricultural Research Station, AAU; Shillongani, Nagaon; District Agricultural office of Marigaon and Nagaon districts with right source of data.

d) Possibility of immediate and wider applicability of the results.
4.2.2 Selection of Blocks

Therefore among the five blocks, one block (Mayong development block) from Marigaon district and two blocks (Batadrava and Rupahi development blocks) out of eighteen blocks from Nagaon district were randomly selected i.e., ten per cent blocks were randomly selected out of the total blocks from each district of the study area.

4.2.3 Selection of Villages and the Respondents

From each selected block, five villages were selected from each block for the investigation, where farmers integrate different enterprises with crop husbandry. As the study involved farmers as the primary respondents; a list of farm families practicing farming activities on regular basis was prepared from each selected village and fifteen numbers of farmers from each village were randomly selected. The farmers were categorized according to the standard norms of the State Department of Agriculture, Assam in different size groups based on the land holding they posses, namely Marginal (below 1 ha), Small (1 to 2 ha), Medium (2 to 3 ha) and Large (3 ha
and above) and primary data from the selected farm household were collected through personal interview method by using a pre-tested questionnaire and schedule. A total of 225 respondents constituted the final sample. Both primary and secondary data were collected for the study. The detailed sampling plan utilized in the study has been depicted for the year of 2010-11 as Table 4.1.

Table 4.1: Selection of Sample Farmers according to the Four Different Categories of Farmers

<table>
<thead>
<tr>
<th>Dev. Block</th>
<th>Name of Village</th>
<th>Marginal</th>
<th>Small</th>
<th>Medium</th>
<th>Large</th>
<th>Aggregate farmers in all groups</th>
<th>No of Sample selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mayaon Dev. Block</td>
<td>Bamunagao</td>
<td>71</td>
<td>7</td>
<td>42</td>
<td>5</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Sonali Kusi N.C.</td>
<td>76</td>
<td>6</td>
<td>54</td>
<td>4</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Naithara</td>
<td>59</td>
<td>6</td>
<td>39</td>
<td>5</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Paliguri</td>
<td>69</td>
<td>7</td>
<td>43</td>
<td>5</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Burha Mayong</td>
<td>58</td>
<td>7</td>
<td>36</td>
<td>4</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>Batadrava Dev. Block</td>
<td>Salaguri</td>
<td>65</td>
<td>6</td>
<td>46</td>
<td>4</td>
<td>18</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Homoraguri</td>
<td>72</td>
<td>7</td>
<td>51</td>
<td>4</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Padumoni</td>
<td>63</td>
<td>7</td>
<td>42</td>
<td>5</td>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Batamari</td>
<td>62</td>
<td>6</td>
<td>32</td>
<td>4</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Solapathar</td>
<td>75</td>
<td>6</td>
<td>41</td>
<td>5</td>
<td>24</td>
<td>3</td>
</tr>
<tr>
<td>Rupahi Dev. Block</td>
<td>Phakuli Pathar</td>
<td>68</td>
<td>6</td>
<td>42</td>
<td>4</td>
<td>19</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Saidoriya</td>
<td>60</td>
<td>6</td>
<td>48</td>
<td>6</td>
<td>14</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Rupahi</td>
<td>64</td>
<td>6</td>
<td>43</td>
<td>4</td>
<td>26</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Sutirpar</td>
<td>70</td>
<td>6</td>
<td>53</td>
<td>5</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Batiyakhali</td>
<td>76</td>
<td>7</td>
<td>57</td>
<td>4</td>
<td>20</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1008</td>
<td>96</td>
<td>669</td>
<td>68</td>
<td>284</td>
<td>41</td>
</tr>
</tbody>
</table>

59
4.3 Analytical Technique

The study was conducted using simple tabular analysis, BCR technique and C-D production functional analysis (Regression model) to fulfill the objectives. Similarly, Linear programming (L.P.) technique was used for optimizing existing farming system and resource use. The analysis was carried out in the computer available in the department of Agricultural Economics and Farm Management, Assam Agricultural University, Jorhat.

4.3.1 Simple Tabular Analysis

The data collected for the study were compiled and tabulated for analysis. These tabulated data was analyzed by taking arithmetic averages and percentages. Through tabulated analysis, No.1 objective of the study was analyzed.

4.3.2 Benefit-cost Ratio Technique

The BCR refers to the ratio of gross return to grand total cost of the respective farming activities. Further it is also interpreted in
this way that the rate of return on production is as a result of one rupee incurred in a particular farming activity. The BCR was worked out by taking into account the remaining value of product at market price and the size of operational cost or grand total cost (fixed cost + variable cost + management cost) of the respective farming activities. It was used to examine No.2 objective of the study. With the help of this technique, the economics of different components of existing farming systems across the various categories of farmers were evaluated.

4.3.3 Functional Analysis

C-D production function (multiple regression models through using SPSS version 16.0) was used to establish a functional relationship of output with its strategic input variables and an attempt was made to examine No.3 objective of the study, i.e., the resource use efficiency level of field crops across various categories of farmers. In fact, this type of production function provides better
fit which has been selected for establishing functional relationship between output and input variables. It is of the following form:

\[ Y = a_1 X_1^{b_1} X_2^{b_2} \cdots X_n^{b_n} \]

Where, \( Y \) is the value of output and \( X_1, X_2, \ldots, X_n \) are the inputs or independent variables; \( b_1, b_2, \ldots, b_n \) are the elasticities of production of the inputs \( X_1, X_2, \ldots, X_n \) respectively.

The function is linear in logarithmic form and can be expressed as follows:

\[ \log Y = \log a_1 + b_1 \log X_1 + b_2 \log X_2 + \cdots + b_n \log X_n \]

The main merit claimed by this function is that it allows greater degree of freedom than that of the quadratic type of function.

The C-D production function has the advantage over others as the estimates can be computed conveniently while the others involve tedious and labourious calculations. The regression coefficient \( (b_i) \) in C-D production function directly indicate the elasticity of
production which measures the percentage change in output for unit percentage change in the input (Bhowmick, 1975).

The C-D production function also facilitates examining the resource use efficiency by comparing marginal value product \((M.V.P.)\) to its factor cost. The marginal value product of a particular input is computed as follows:

\[ M.V.P. \text{ of } \bar{X}_i = b_i \frac{\bar{Y}}{\bar{X}_i} \]

Where, \(\bar{Y}\) = Geometric mean of value of output.

\(\bar{X}_i\) = Geometric mean of \(i^{th}\) independent variable.

\(b_i\) = The regression coefficient of the \(i^{th}\) independent variable.

For examining the economic efficiency of resource use levels, the ratios of marginal value productivities to Marginal factor cost (factor cost) were computed. The ratio of \(MVP/MFC\) indicates whether a particular input has been used efficiently or not.

The over-all price of the different prices of seeds was taken as its marginal cost. Marginal cost for family and hired labour was the hiring cost of human labour at the prevailing market price. For FYM, the price per quintal was taken as its marginal cost. The
market prices of fertilizer and pesticides were taken as marginal factor cost.

Thus, when,

\[ \frac{MVP}{MFC} = 1, \]

then efficiency of input use is optimum.

\[ \frac{MVP}{MFC} > 1, \]

then there is a scope of use of more input to have more production.

\[ \frac{MVP}{MFC} < 1, \]

then input has been overused.

4.3.3.1 The Variables

As the study involves production function analysis, the economic variables are necessarily outputs and inputs. The following variables were included in the multiple regression models. Descriptions of variables as well as computational procedures adopted to measure them are as under:

4.3.3.1.1. Dependent variables

Output \((Y)\)

The gross value of output has been defined in value of crop return i.e., in rupees.
4.3.3.1.2. Independent variables

Seed \((X_1(1))\)

The expenditure on the seeds measured in money value.

FYM \((X_1(2))\)

It was measured as total expenditure of farm yard manure used in the cultivation process. It is also measured in rupees.

Fertilizer \((X_1(3))\)

It was measured as total expenditure incurred in purchasing the fertilizer in terms of rupees.

Pesticides \((X_1(4))\)

The value of pesticides included the amount of expenditure on pesticides incurred in cultivation of different crop activities in the farm. It was measured in terms of rupees.

Family Human Labour \((X_5)\)

Family human labour included male, female and child as helper. Female and child were converted to male adult equivalent using the following conversion ratio \((1:0.75:0.50)\):
1 female labour = 0.75 male labour.

1 child as helper = 0.50 male labour.

Here, it is considered that one manday is equivalent to eight hours of labour of an adult male worker. The variable was measured as total expenditure of mandays in money value.

**Hired Human Labour \((X_6)\)**

Hired human labour included both casually hired and permanently hired labour. Permanently hired labour included male and child as helper. The variable was measured as mandays. All conversion and specification was followed as in family labour and the variable was measured as total expenditure on mandays in rupees.

### 4.3.4 The Programming Model

Among different conventional analytical techniques, the Linear Programming technique is a more systematic and accurate method of determining mathematically the optimum combination of large number of enterprises with various input constraint within the
limits of available resources. When the number of real activities is quite large, the conventional budgeting technique becomes incapable of giving a unique solution.

The LP technique has the advantage of solving such type of problems precisely and quickly. This technique originated in World War II out of necessity to specify ship routes for quickest and least-cost distribution of supplies on various war fronts and to allocate labour, machine tools and other such resources optimally to generate maximum war production (Johl and Kapur, 1977).

L.P. technique has been used in agriculture almost since its very development and exclusively use in the field of agriculture by Heady and Candler in 1958. At present, the technique is also being progressively utilized in finding solutions to various economic problems and in planning the farm enterprise mix with a view to maximizing the objective function.

For optimization of farm plans (No.4 objective of the study was analyzed through using Tora Optimization System, Windows @ version 2.00) data used in the linear programming model were (a)
data for technological matrix, (b) data for resource supplies and (c) data for prices.

4.3.4.1 Selection of Farming Activities for Programming

Altogether 16 crop and livestock/birds activities for marginal and small farmers, 17 crop and livestock/birds activities for medium and large farmer groups were incorporated in the synthetic plans. Following crop activities were identified and included in the synthetic plans.

A 01: Sali paddy local
A 02: Sali paddy HYV
A 03: Kharif pulse
A 04: Kharif vegetables
A 05: Rabi pulse
A 06: Rabi vegetables
A 07: Mustard
A 08: Potato
A 09: Summer paddy local
A 10: Summer paddy HYV
A 11: Jute
The livestock activities included in the synthetic plans were as under:

B 12 : Dairy cow local: 3 cows per unit for milk and cowdunck production

B 13 : Dairy cow CBs: 2 cows per unit for milk and cowdunck production

B 14 : Goatery: 6 goats per unit for meat production

B 15 : Poultry: 30 layers per unit for egg and meat production

B 16 : Duckery: 25 ducks per unit for egg and meat production

B 17 : Pigeon: 10 pigeons per unit for meat production

In total four synthetic farm plans were developed for various size groups of farms.

4.3.4.2 The Input-Output Coefficients

The input-output coefficients for the technological matrix were comprised of the resource requirements and output produced per unit of the activity included in the programme. The input-output coefficient of various activities required for the synthetic plans for
the four size groups of farmers were derived by averaging the collected data from the sample farms, as it has been assumed that the best estimate of input-output coefficients would be the average input-output coefficients obtained from the sample farms.

4.3.4.3 Resource Constraints or Resource Supplies

The resources of a farm consist of land, family human labour, cash or working capital required to buy such inputs as seed, fertilizers, pesticides, hired human labour and machinery, etc. The availabilities of these resources act as constraints within which the feasible planning needs to be optimized. In the programming model, the resource constraints used as follows:

4.3.4.3.1 Land

In general, agricultural year is divided into two broad seasons viz., kharif and rabi. However for practical suitability the agricultural year has been classified into three seasons, viz., (a) Kharif season (mid June to mid October), (b) Rabi season (mid
October to mid February) and (c) Summer season (mid February to mid June).

Land being the scarcest resource limiting the level of activities to be incorporated in the plan was classified into 3 categories viz., upland, medium land and low land. Upland, medium and low lands constitute the land availability for the cultivation of kharif season. It is noteworthy to be mentioned here that upland and medium land constitute the land availability for the cultivation of rabi season, while medium and low level of land form the size of land for the cultivation of summer season. Land for livestock/birds was not incorporated in the land constraint, as it does not require the land of field crops, hence it would not affect on the production of field crops. Similarly land under plantation crop (perennial) was not incorporated in the programming model and it was analyzed separately under the head of homestead plantation crops. The land constraints used in the programming model were as follows:

\[ \sum_{i=1}^{n} a_{is} X_i \leq A_s \quad (s = 1 \ldots 3) \]

Where, \( a_{is} \) = Land coefficient for \( i^{th} \) crop activity in \( s^{th} \) season.

\( X_i \) = Activity level of \( i^{th} \) crop activity.

\( A_s \) = Land availability in \( s^{th} \) season.
4.3.4.3.2 Family Human Labour (FHL)

Family human labour was another important resource generating restriction on the level of activities produced in the plan. The data regarding the available human labour had been collected from the sampled farms. These human labour were put in the model according to the seasons of crops grown, i.e., kharif, rabi and summer season. The availability of human labour was worked out in terms of adult mandays on the basis of 1:0.75:0.50 for men, women and child respectively. However because of the non-availability of data regarding the quality of labour, the labour unit could not be categorized based on the quality differences. To calculate the available labour unit in each season, the number of days of works due to religious, festivals, social needs, leisure, odd off days during which farm operations were suspended, children’s school, illness and other purposes were deducted from total number of calendar days in the season. The wage rate prevailing in the study area was considered in calculating the wage rates of labour. The family human labour availability for farm work comes from family
members working on the farms and permanently attached workers. Thus, the family human labour constraints used for field crops were as follows:

\[ \sum_{i=1}^{n} f_{is} X_i + 1 \leq H_s \quad (s = 1, \ldots, 3) \]

And for livestock / birds activities

\[ \sum_{i'=-1}^{n} f_{i's} X_{i'-1} - 1 \leq H'_s \quad (s = 1), \text{ where } 1 \text{ yr is assumed as a season} \]

Where, \( f_{is} \) = Family human labour required for \( i^{th} \) crop activity in \( s^{th} \) season.

\( X_i \) = Activity level of \( i^{th} \) crop activity.

\( f_{i's} \) = Family human labour required for \( i^{th} \) livestock / birds activity.

\( X_{i'} \) = Activity level of \( i^{th} \) livestock/birds activity.

\( H_s \) = Available family human labour in \( s^{th} \) season.

\( H'_s \) = Availability family human labour in \( s^{th} \) season.

The transfer activities are introduced in the model to take care of certain aspects such as transfer of stock resources from one period to another. The transfer activity in the matrix can be shown by introducing ‘+1’ against what is transferred out and ‘-1’ against what it is transferred in and ‘0’ is placed as element in the \( C_j \) row.
against this column, (Kahlon and Singh, 1992). In the study area, as surplus family human labour were available in all the three seasons for all the farming categories, hence this surplus labours were transferred to livestock/birds activities. Therefore the ‘±’ sign was introduced in the constraints of field crops and livestock/birds activities respectively.

4.3.4.3.3 Hired Human Labour (HHL)

It is obvious that hired human labour is also essential for operating agricultural activities as well as for livestock activities. Further it needs to be mentioned that optimal farm plans were developed with a view to increase the net income by provision of labour hiring activities in the synthetic plans. The constraint of hired human labour for field crops was as follows:

\[ \sum_{i=1}^{n} h_{is} X_i \geq 0 \quad (s=1,\ldots,3) \]

For livestock / birds activities, the constraint was as follows:

\[ \sum_{i=1}^{n} h_{is} X_i \geq 0 \quad (s=1) \], where one year is assumed as a season
Where, $h_s =$ Hired human labour required for $i^{th}$ crop activity in $s^{th}$ season.

$X_i =$ Activity level of $i^{th}$ crop activity.

$h_{rs} =$ Hired human labour required for $i^{th}$ livestock/birds activity.

$X_r =$ Activity level of $i^{th}$ livestock / birds activity.

4.3.4.3.4 Capital

The working capital was defined as the expenses to meet the day to day crop production or livestock rearing expenses in money terms. These capital constraints were used for three seasons in the programming model. Since the direct estimation of capital availability was not possible due to the insufficient records available with the farmers and the difficulty in sorting out the family farm expenditures, so the availability of capital at the farm level was estimated by the variable expenses incurred during the season by farmers.

The term working capital (variable expenses) included the following items:

i) Value of seed (purchased)

ii) Cost of hired FYM, fertilizer and pesticides
iii) Fuel charges for Irrigation

iv) Hired human labour

v) Hired bullock labour

vi) Hired machine labour

vii) Purchase of livestock/birds feeds and veterinary expenses.

Thus, the capital constraints for field crops incorporated in the programming model were of the following form:

\[ \sum_{i=1}^{n} c_{is} X_i \pm 1 \leq C_s \quad (s = 1, ..., 3) \]

For livestock activities, the form of capital constraint was as follows:

\[ \sum_{r=1}^{m} c_{irs} X_r - 1 \leq C'_s \quad (s = 1), \text{ where one year is assumed as a season} \]

Where, \( c_{is} = \) Capital requirement per hectare of \( i^{th} \) crops activity in \( s^{th} \) season.

\( c_{irs} = \) Capital requirement per unit of \( i^{th} \) livestock/birds activity in \( s^{th} \) season.
\[ C_s = \ \text{Availability of working capital for crops activities in}\]
\[ s^{th} \text{ season}. \]
\[ C_s' = \ \text{Availability of working capital for livestock / birds activities.} \]

It needs to be mentioned that the borrowing activity is introduced for such resource which can be supplemented. For instance if capital which can be borrowed is scarce with the farmer and may be willing to borrow this resource so long as its MVP is higher than its acquisition cost, this can be introduced. In the column of the borrowing activity against the respective resource (constraint), -1 is introduced and its cost of acquisition per unit is shown in the objective function with negative sign, (Kahlon and Singh, 1992).

It was observed that although working capital was found to be scarce in the existing plan of each category of sample farmers, but all the categories of farmers were allowed to borrow capital for each season to develop optimal plan and whatever the surplus capital was left, that surplus amount was transferred to livestock/bird enterprise.
The marginal and small farmers were allowed to borrow Rs.1000/-, Rs.700/- and Rs.1200/- in each season at the rate of 10% interest rate. Similarly medium and large category of farmers were allow to borrow Rs. 1000/-, Rs. 1200/- and Rs. 2200/- at the rate of 10% interest for the three seasons respectively. The amount was fixed on the basis of information about capability of farmers to borrow, collected directly from sampled farms. Further, as capital was found to be surplus in each season, hence these surplus capitals were transferred to the livestock/birds activities in the optimal plan for all the categories of farmers. Therefore, the ‘+’ sign was introduced in the capital constraint of each season of field crops, and the ‘−’ sign was placed in the column of capital transfer activity.

4.3.4.3.5 Minimum Area Restrictions for certain Crops

Among majority of the farmers in the study area, it is a common practice to devote some minimum areas under some specific crops of their field to meet their festivals and domestic needs. So, minimum area constraints were developed from the information collected from sampled farmers and incorporated in the
synthetic plans of the programming model which was as shown in Table 4.2. The constraints were of the following form:

\[ \sum_{i=1}^{n} a_{is} X_i \geq D_i \quad (i=1, \ldots, 6) \]

Where, \( a_{is} = \) Land required per unit of \( i^{th} \) crop activity in \( s^{th} \) season.

\( D_i = \) Minimum area devoted for specific crop activity by the farmers in \( i^{th} \) activities.

Table 4.2: Maximum and Minimum Restrictions of Crops Area

<table>
<thead>
<tr>
<th>Field crops</th>
<th>Unit</th>
<th>Minimum area restrictions</th>
<th>Maximum area restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Marginal</td>
<td>Small</td>
</tr>
<tr>
<td>Sali paddy local</td>
<td>Ha</td>
<td>0.17</td>
<td>0.18</td>
</tr>
<tr>
<td>Kharif vegetables</td>
<td>Ha</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Rabi pulses</td>
<td>Ha</td>
<td>0.05</td>
<td>0.04</td>
</tr>
<tr>
<td>Mustard</td>
<td>Ha</td>
<td>0.04</td>
<td>0.06</td>
</tr>
<tr>
<td>Summer paddy local</td>
<td>Ha</td>
<td>0.15</td>
<td>0.12</td>
</tr>
<tr>
<td>Jute</td>
<td>Ha</td>
<td>0.04</td>
<td>0.06</td>
</tr>
<tr>
<td>Potato</td>
<td>Ha</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sali paddy HYV</td>
<td>Ha</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Summer paddy HYV</td>
<td>Ha</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rabi vegetables</td>
<td>Ha</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kharif pulse</td>
<td>Ha</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
4.3.4.3.6 Maximum Area Restrictions for Crops

Certain crops were highly remunerative, land specific and at the same time risky also. If restrictions were not imposed for these crops, entire cultivated area for the entire season will be taken by these crops, which is not materialized in reality. As for example, the area under rabi vegetables, kharif vegetables, etc., are highly remunerative, but risky enterprises in the study area were kept limited because farmers would not like to place all their eggs in one basket. Further, due to limited resource availability, farmers of the study area kept maximum range of land area for some specific crops which are remunerative, even though the crops might not be risky.

Hence, maximum area restrictions based on farmer’s perception were put under these crops and included in the model. The maximum area restrictions for various crops are shown in Table 4.2.

\[ \sum_{i=1}^{s} a_{is} X_i \leq D'_i \quad (i = 1 \ldots \ldots 5) \]

Where, \( a_{is} = \) Land required per unit of \( i^{th} \) crop activity in \( s^{th} \) season.

\( D'_i = \) Maximum area devoted for specific crop activity by the farmers in \( i^{th} \) activities.
4.3.4.3.7 Maximum number of Livestock/birds

Resource endowment position particularly infrastructure and equipment as well as skill of the sample farmers were limited because of which they cannot afford to keep as many livestock/birds as they wish even though they were highly profitable. Hence, restriction on the maximum number of livestock for each category that could be kept and managed by them were put on the model on the basis of their own opinion. The form of constraint of maximum livestock/birds was as follows:

$$\sum_{i'=1}^{m} I_{i'} X_{i'} \leq L_{i'} \quad (i' \leq 5 \text{ or } 6)$$

Where $L_{i'} = \text{Maximum number of livestock/birds.}$

The maximum number fixed for each category of livestock / birds for four different category of sample farmers were presented in Table 4.3.
Table 4.3: Minimum and Maximum restriction of livestock/birds

<table>
<thead>
<tr>
<th>Livestock/birds</th>
<th>Unit</th>
<th>Nos. of restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum restriction of livestock/birds</td>
</tr>
<tr>
<td>Dairy cow local</td>
<td>Nos.</td>
<td>1 (0.33)</td>
</tr>
<tr>
<td>Dairy cow CBs.</td>
<td>Nos.</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td>Goatery</td>
<td>Nos.</td>
<td>2 (0.33)</td>
</tr>
<tr>
<td>Poultry</td>
<td>Nos.</td>
<td>5 (0.17)</td>
</tr>
<tr>
<td>Duckery</td>
<td>Nos.</td>
<td>4 (0.16)</td>
</tr>
<tr>
<td>Pigeon</td>
<td>Nos.</td>
<td>2 (0.20)</td>
</tr>
</tbody>
</table>

Figures within parentheses indicated in unit of livestock/birds

4.3.4.3.8 Minimum number of Livestock/birds

Likewise, farmers were interested to keep certain minimum number of livestock/birds even which may be profitable, a practice carried out more out of a tradition than to support them in their living. The minimum number of each category of livestock/birds that
were preferred by the sample farmers and included in the model is also presented in Table 4.3. The constraint form of the minimum number of livestock/birds was as follows:

\[ \sum_{i=1}^{m} l_{i} X_{i} \geq L'_{i} \quad (i' \leq 5 \text{ or } 6) \]

Where, \( L'_{i} = \) Minimum number of livestock/birds.

4.3.4.4 Objective Function

Development of the optimal plans from the synthetic plans was aimed to maximize farm net returns in an annual cycle, subject to the different constraints mentioned above. The objective function of the model was termed as \( C_j \text{ row} \). The per hectare/unit of gross value of the products and the value of the inputs for crops, livestock and other activities were estimated on the basis of reference year price. Gross returns include the value of main product and the by-product. The gross return per hectare and unit for the crop and livestock production activities was estimated by multiplying the yield by its unit price. In order to maintain uniformity, the output prices were taken as the harvest prices and the input prices as the
actual market prices at the time of application of inputs. Due to lack of information regarding farm harvest price, average price received by the total sampled farm for each activity was taken as farm harvest price of the study area. Per hectare grand total cost for fields crops (fixed cost + variable cost + management cost) and grand total cost of livestock/birds (fixed cost + variable cost + management cost) per unit were worked out. The $C_j$ (net return per hectare/unit) value for each of the field crops and livestock/birds production activities were then calculated for the existing technology by deducting the per hectare/unit grand total cost from its gross return. These per hectare/unit net returns of each field crop and livestock/bird activity were shown as in the appendix tables (from Appendix I to XI and Appendix XIII To XVIII). Thus the objective function of the synthetic farm plan was of the following form:

$$\max Z = \sum_{i=1}^{n} R_i X_i + \sum_{r=1}^{m} R_r X_r$$

Where, $Z =$ Total net return

$R_i =$ Net return per hectare of $i^{th}$ crop activity.

$X_i =$ Activity level of $i^{th}$ crop activity.
\( R'_{i} \) = Net return per unit of \( i^{th} \) livestock / birds activity.

\( X'_{i} \) = Activity level of \( i^{th} \) livestock / birds activity

The deterministic linear programming model developed and used in the study was as follows:

Max. net return
\[
Z = \sum_{i=1}^{n} R_i X_i + \sum_{r'=1}^{m} R_{r'} X_{r'}
\]

Subject to,
\[
\sum_{i=1}^{n} a_{is} X_i \leq A_s \quad (s = 1 \ldots 3) \quad \text{(Land)}
\]
\[
\sum_{i=1}^{n} f_{is} X_i + 1 \leq H_s \quad (s = 1 \ldots 3) \quad \text{(Family human labour for field crops)}
\]
\[
\sum_{r'=1}^{m} f_{r's} X_{r'} \leq H_s' \quad (s = 1) \quad \text{(Family human labour for livestock/birds)}
\]
\[
\sum_{s=1}^{3} h_{0s} X_s \geq 0 \quad (s = 1 \ldots 3) \quad \text{(Hired human labour for field crops)}
\]
\[
\sum_{r'=1}^{m} h_{r's} X_{r'} \geq 0 \quad (s = 1) \quad \text{(Hired human labour for livestock/birds)}
\]
\[
\sum_{i=1}^{n} c_{is} X_i \pm 1 \leq C_s \quad (s = 1 \ldots 3) \quad \text{(Capital for field crops)}
\]
\[ \sum_{i=1}^{m} c_{is} X_{s} + 1 \leq C_{s}' \quad (s = 1) \] (Capital for livestock/birds)

\[ \sum_{i=1}^{n} a_{is} X_{i} \geq D_{j} \quad (j = 1 \ldots 6) \] (Minimum area restriction for specific crops)

\[ \sum_{i=1}^{n} a_{is} X_{i} \leq D_{j} \quad (j = 1 \ldots 5) \] (Maximum area restriction for specific crops)

\[ \sum_{i=1}^{m} l_{is} X_{i} \leq L_{i}' \quad (i' \leq 5 or 6) \] (Maximum number of livestock/birds)

\[ \sum_{i=1}^{m} l_{is} X_{i} \geq L_{i}' \quad (i' \leq 5 or 6) \] (Minimum number of livestock/birds)

Non-negativity constraints:

\[ X_{i} \geq 0, \quad X_{i}' \geq 0 \]

### 4.3.4.5 Optimal Plan

The study was conducted to assess the potentiality of increasing farm net income and human labour employment for marginal, small, medium and large size groups of farms. Optimal plans were evolved with the addition and deletion of different activities and constraints to meet the objectives of the study. The optimal plans developed for the study were as follows:
\[ P_0 = \text{Existing plan for four different categories of farmers} \]

\[ P_1 = \text{Optimal plan for marginal category of farmers with existing technology} \]

\[ P_2 = \text{Optimal plan for small category of farmers with existing technology} \]

\[ P_3 = \text{Optimal plan for medium category of farmers with existing technology} \]

\[ P_4 = \text{Optimal plan for large category of farmers with existing technology} \]

In total, there were 4 existing plan \((P_0)\) for different category of farmers. Thus, there would be 4 optimal plans with existing technology corresponding to 4 existing plan \((P_0)\) for the present study.

4.3.4.6 Assumptions underlying the model

The following assumptions are made in the model:

i) The short term (variable) capital inputs such as seed, fertilizer, FYM, pesticides, feeds, medicines, etc., will be available in right quantity and at right time and place as per requirement.

ii) Adequate distribution of rainfall and availability of irrigation as per requirement are expected.
iii) There will be no shortage of credit, i.e., credit will be liberal. Financial institutions (formal) are expected to function satisfactorily to meet the requirement of capital to the farmers whatever amount is needed.

iv) There will be adequate marketing facilities for supplying the requisite capital inputs and selling the surplus products of the sample farmers.

v) Functioning of the extension agencies will be improved as per need of the sample farmers.