CHAPTER – 7

OPTIMUM PLAN FOR MARGINAL FARMERS USING GOAL PROGRAMMING

7.1 GOAL PROGRAMMING (G.P.)

The goal programming was proposed by Chames & Cooper for a linear model. It has been further developed by Ijiri, Lee and Ignizio et. al. The method require the D.M. to set goals for each objective that he / she wishes to attain. As the solution of any L.P.P. is limited by quantification. Unless management can accurately quantify the relationship of the variables in cardinal numbers, the solution is only as good as the inputs. The distinguishing characteristic of goal programming is that it allows for an ordinal solution. Stated differently, planner may be unable to obtain information on the cost or value of a goal or a sub-goal, but often upper or lower limit may be stated for each sub-goal. Usually the planner (D.M.) can determine the priority of the desired attainment of each goal or sub-goal and face the problems of the allocation of scarce resources obviously it is not always possible to achieve every goal to the extent desired by planner (D.M.). Thus with or without goal programming the planner attaches a certain priority to the achievement of particular goal.

Priority ranking the goal programming solution will allow some lower priority goals to go unsatisfied in order that higher priority goals, which may conflict with lower priority goals to achieve the targets. Thus ranking of deviational variables which appears in the objective function is the most important step in formulating a goal programming which consist of incompatible goals. According to this, the highest priority factor is assigned to the deviational variable of the most important goal. The lowest priority is assigned to deviational variable of the least important goal. Thus the low order goals are considered only after higher goals are achieved as desired. The priority factors have the relationship $P_j >>> P_{j+1}$• The priority relationship indicates that if lower order goals is multiplied by n however...
large n may be even than it cannot be as important as the higher goals.

Weighing factors deviational variables within some priority level can be ordered in an ordinal sequence based on their importance relative to each order. This can be obtained by weighing deviational variable within the same priority level. The higher weighing factor assigned to any deviational variable, the more important that variable is. The deviational variable and ordinal priority factors are always present in each objective function. The weights need not always be assigned but are useful when needed.

Goal programming is linear mathematical model in which the optimum attainment of multiple goals is sought within the given decision environment. The variables constraints and the objective function is given below.

The standard goal programming model is

\[
\min \quad Z = d^+ + d^-
\]

subject to \( f(x) - d^+ + d^- = g_o \)  \hspace{1cm} (7.1)

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

\hspace{1cm} (7.2)

\( i = 1, 2, \ldots, m \)

\( x_j \geq 0, \quad d^- \geq 0 \)

Here \( g_o \) is the desired goal which we would like the objective function

\[
f(x) - \sum_{j=1}^{n} C_j x_j \]

to achieve as close as possible subject to constraints
Also \( c_i^* \) denotes the amount \( b_j \) which the goal go is underachieved and \( d^+ \) denotes the amount by which the goal go is over achieved by the objective function. Obviously goal go cannot simultaneously overachieved as well underachieved. It will be either exactly achieved (in which case \( d^- = 0 = d^+ \)) or overachieved (in which case \( o,d + > 0 \)) or under achieved (in which case \( d^- = 0, d^+ > 0 \)). Hence only those solutions are acceptable in which at least one of the \( d^- \cdot d^+ = 0 \).

In above model, it is assumed that any of the alternative situations in which the goal is achieved or over achieved / underachieved is acceptable. However, in case it is desired that \( d^- = 0 \), in the above model. Similarly if overachievement of the goal is not desired than \( d^+ = 0 \) in the above model.

### 7.2 GOAL PROGRAMMING FORMULATION

The goal programming is composed of two types of constraints. They are goal and non-goal constraints. Each goal may be assigned to positive or, negative deviational variable or both. Three possibilities exist for each goal or constraints equation. The L.H.S. can be less than or equal to or greater than or exactly equal to the R.H.S. these three possibilities and how they are handled in G.P. formulations are shown here.

<table>
<thead>
<tr>
<th>Type</th>
<th>Goal or Constraint type</th>
<th>Processed goal or constraint</th>
<th>Deviational variable to minimized in the objective function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( f_i(x) \leq b_i )</td>
<td>( f_i x \hat{d} - d_i^+ = b_i )</td>
<td>( d_i^+ )</td>
</tr>
<tr>
<td>2</td>
<td>( f_i(x) \geq b_i )</td>
<td>( f_i x \hat{d} - d_i^- = b_i )</td>
<td>( d_i^- )</td>
</tr>
<tr>
<td>3</td>
<td>( f_i(x) = b_i )</td>
<td>( f_i x \hat{d} - d_i^- = b_i )</td>
<td>( d_i^- + d_i^+ )</td>
</tr>
</tbody>
</table>
The general G.P. model with priorities can be presented below

\[ \text{Min } Z = \sum_{k=1}^{K} P_k \sum_{i=1}^{m} w_i - d_i^- + d_i^+ \]

Subject to \[ \sum_{j=1}^{n} a_{ij} x_{ij} + d_i^- - d_j^+ = b_i \quad i, 1,2,\ldots,m \]

\[ x_j, d_j^-, d_i^+ \geq 0 \]

In this model, \( P_k \) is the preemptive priority factor assigned to goal, \( w_i, w_i^+ \) are numerical weights assigned to the deviations goal \( i \) at a given priority level, \( d_i^- \) and \( d_i^+ \) are the negative and positive deviations respectively, \( a_{ij} \) is the technological coefficient of \( x_j \) in goal \( i \) and \( b_i \) is the R.H.S. value of goal.

In the usual L.P. formulation for maximizing total net return, the function \( z \) is taken as the objective function and the decision variable are 'iI'- determined so as to maximize \( z \) subject to the constraints and the optimum value of \( Z \) as Rs. 102320.16.

The G.P. approach minimizes the deviations between the target levels and the actual result by transforming the targets into the goal constraints. In our G.P. Plan we set up the net return goal constraints is as under

\[ \sum_{j=1}^{19} C_j x_j + \sum_{j=21}^{32} C_j x_j + \sum_{j=33}^{36} C_j x_j + d_i^- - d_i^+ = 102326.16 \]  

\[ 7.1a \]

The target for the total net returns was set at Rs. 118859.06 in order to offer the farmer a net returns as close as possible to the one offered by the L.P. (i.e. the maximum returns solution)

The negative deviational variable \( (d,^-) \) measures the under achievement of the goal with respect to its target. The positive deviational variable \( (d,^+) \) plays just the opposite role, that is it measures the
amount by which the goal has surpassed its own target. In order to obtain the desired level of goal (7.19) the negative deviational variable ($d_i$) must be minimized. So the goal programming formulation of our problem is:

$$\text{Min } U = d_i$$

Subject to the constraints (7.1) where $d_i$ is the under achievement in the constraint (7)

The optimum value of the objective function $U_{opt} = \Box$

Hence, the optimum value of the net returns is Rs. 102320.16

7.3 INTERPRETATION OF THE OPTIMUM SOLUTION

Result of the GP plan 7.1 are described under the following heads:

I. Net return from agricultural activities.
II. Deployment of labour on various activities
III. Net return from livestock activities

<table>
<thead>
<tr>
<th>Variable</th>
<th>Interpretation of Variable</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$X_1$</td>
<td>Bajra-wheat (H.Y.V.) Crop Rotation</td>
<td>.021</td>
</tr>
<tr>
<td>$X_2$</td>
<td>Maize-wheat (H.Y.V.) Crop Rotation</td>
<td>.129</td>
</tr>
<tr>
<td>$X_4$</td>
<td>Paddy (H.Y.V.) - wheat (H.Y.V.) Crop Rotation</td>
<td>.16</td>
</tr>
</tbody>
</table>
\[ X_{13} \] Sugar Can (768) Crop Rotation \[ .20 \]
\[ X_{17} \] Bajra + Urd - Unused Crop Rotation \[ .11 \]
\[ X_{18} \] Maize -- Arhar (Unirrigated) Crop Rotation \[ .07 \]
\[ X_{20} \] Bullock \[ 1.00 \]
\[ X_{21} \] Employment outside in the month of July \[ 32.37 \]
\[ X_{22} \] Employment outside in the month of August \[ 34.67 \]
\[ X_{23} \] Employment outside in the month of September \[ 38.91 \]
\[ X_{24} \] Employment outside in the month of October \[ 28.80 \]
\[ X_{25} \] Employment outside in the month of November \[ 26.10 \]
\[ X_{26} \] Employment outside in the month of December \[ 37.38 \]
\[ X_{27} \] Employment outside in the month of January \[ 40.89 \]
\[ X_{28} \] Employment outside in the month of February \[ 42.88 \]
\[ X_{29} \] Employment outside in the month of March \[ 43.32 \]
\[ X_{30} \] Employment outside in the month of April \[ 35.10 \]
\[ X_{31} \] Employment outside in the month of May \[ 38.48 \]
\[ X_{32} \] Employment outside in the month of June \[ 39.04 \]
\[ X_{35} \] Buffalo (Murrah) \[ 2.00 \]
\[ X_{36} \] (SahiwaJ x Jersey) Cow \[ 1.00 \]
\[ d_5 \] Deviational Variable \[ .11 \]
\[ d_6 \] Deviational Variable \[ .11 \]
\[ d_9 \] Deviational Variable \[ .02 \]
\[ d_{10} \] Deviational Variable \[ .09 \]
\[ d_{24} \] Deviational Variable \[ 38.4 \]
\[ d_{25} \] Deviational Variable \[ 204.3 \]

(i) Net return from agricultural activities:

The table 7.2 presents the actual area (in ha) and their percentages under crop rotation. The actual net returns (in Rs.) and percentage net returns of these crop rotations are also calculated.

**Table No. 7.2 : Net Return from Agricultural Activities**
<table>
<thead>
<tr>
<th>Sno</th>
<th>Crop Rotation</th>
<th>Area return per ha (in Rs.)</th>
<th>Total Net Return (in Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bajra-Wheat(HYV)</td>
<td>.021(3.04%)</td>
<td>517.23</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(3.24%)</td>
</tr>
<tr>
<td>2</td>
<td>Maize – wheat (HYV)</td>
<td>.129(18.6%)</td>
<td>3249.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(20.38%)</td>
</tr>
<tr>
<td>3</td>
<td>Paddy (HYV)-Wheat (HYV)</td>
<td>.16(23.99%)</td>
<td>3998.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(25.08%)</td>
</tr>
<tr>
<td>4</td>
<td>Sugar cane (768)</td>
<td>.20(28.99%)</td>
<td>6048</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(37.94%)</td>
</tr>
<tr>
<td>5</td>
<td>Maize + Arhar (Unirrigated)</td>
<td>.07(10.14%)</td>
<td>896.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(5.62%)</td>
</tr>
<tr>
<td>6</td>
<td>Bajra + Urd (Unirrigated)</td>
<td>0.11(15.94%)</td>
<td>1229.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(7.7%)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>15939.16</td>
</tr>
</tbody>
</table>

Also, Used irrigated area = .48 ha
Used irrigated area = .21 ha
Total unused land = NIL

Table No. 7.2 determines that only six crop rotations are beneficial to the farmers and the total area of the land has been used. The maximum area (28.99%) of the total utilized area is occupied by the crop rotation "Sugar cane (768)". Therefore, the maximum 37.90% out of total net return is contributed by this crop rotation. It was found that the crop rotation "Bazra Wheat (H.V.Y.)" contributed the least net return to the total net return. It is also observed from the result that the
contribution of the irrigated land to the net return was much higher in comparison to the contribution of unirrigated land.

Table No. 7.3

DEPLOYMENT OF LABOUR ON VARIOUS ACTIVITIES

<table>
<thead>
<tr>
<th>Sno.</th>
<th>Month</th>
<th>Available Labour m.d</th>
<th>Labour used in inside activities</th>
<th>Labour used on outside</th>
<th>Total net return (in Rs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Land in m.d</td>
<td>Livestock (in m.d)</td>
<td>Bullock (in m.d.)</td>
</tr>
<tr>
<td>1</td>
<td>Jul</td>
<td>92</td>
<td>19.63</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Aug</td>
<td>92</td>
<td>17.33</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Sep</td>
<td>92</td>
<td>13.09</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Oct</td>
<td>85</td>
<td>16.20</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Nov</td>
<td>85</td>
<td>18.90</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Dec</td>
<td>85</td>
<td>7.62</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>Jan</td>
<td>85</td>
<td>4.11</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>Feb</td>
<td>92</td>
<td>9.12</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>Mar</td>
<td>90</td>
<td>6.68</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Apr</td>
<td>92</td>
<td>46.69</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>11</td>
<td>May</td>
<td>85</td>
<td>6.52</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>12</td>
<td>Jun</td>
<td>85</td>
<td>5.96</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>1060</td>
<td>171.85</td>
<td>420</td>
<td>60</td>
</tr>
</tbody>
</table>
(ii) **Deployment of labour on various activities:**

The monthwise family labour distribution in mandays on various activities is presented in the table no. 7.3.

It is found from the table no (7.3) that the maximum number of mandays used in the month of January. It is also clear from the table (7.3) the net return is ranging between Rs. 1566.00 to Rs. 2730.00. Another striking feature is that the family labour gets more net return in the first six months of the year. It is included that the farmer can earn an average amount of 45969.7 per year by proper outside employment of their family members.

(iii) **Net return through livestock activities:**

The optimum number of milch animals and corresponding net returns are shown in table no. (7.4).

<table>
<thead>
<tr>
<th>Sno.</th>
<th>Animal breed</th>
<th>No. of Animals</th>
<th>Net returns per animals (in Rs.)</th>
<th>Total net return in (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Buffalo (Murrah)</td>
<td>2</td>
<td>22392</td>
<td>44784</td>
</tr>
<tr>
<td>2</td>
<td>Sahiwal x Jersey Cow</td>
<td>1</td>
<td>14220</td>
<td>14220</td>
</tr>
<tr>
<td></td>
<td>Cow</td>
<td></td>
<td></td>
<td><strong>59004</strong></td>
</tr>
</tbody>
</table>

The table no (7.4) shows that only the animals Buffalo (Murrah) and (Sahiwal X Jersey) Cow
contributed the net return from livestock activities. It is found that Buffalo giving 75.02% of the total net returns from livestock is more profitable as comparison to the cow. An amount 59004 comes out as the total net return from live stock activities which is higher as compare to the net return from other activities.

### 7.4 SUMMARY RESULT OF GP PLAN

On the basis of Table No. (7.2), (7.3) and (7.4) the total net returns and return per manday for marginal farmers under OP Plan 7.1 are summarized and Table No. 7.5.

<table>
<thead>
<tr>
<th>Source</th>
<th>Net Returns (in Rs.)</th>
<th>Contribution to total net return</th>
<th>Labour use in m.d.</th>
<th>Net return per m.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Activity</td>
<td>15939.16</td>
<td>15.57%</td>
<td>141.77</td>
<td>18.76</td>
</tr>
<tr>
<td>Labour employment outside</td>
<td>27377</td>
<td>26.76%</td>
<td>438.55</td>
<td>10.51</td>
</tr>
<tr>
<td>Milch animals</td>
<td>59004</td>
<td>57.67%</td>
<td>420.00</td>
<td>22.60</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>102320.16</strong></td>
<td><strong>100%</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It is clear from the table no. 7.5 that more amount is coming from milch animals and minimum contribution is from agricultural activity.
From the last column of the table no. 7.5, we find that labour profitability from outside employment is least while the labour profitability from livestock is higher than from the agricultural activities. Therefore, livestock activity is more beneficial and important for the marginal farmer than the agricultural activity and the government should encourage and educate the farmers to take up dairying practices. Moreover, we find that under this plan

\[
\text{Capital profitability from agricultural activity} = \frac{\text{Net Return from Land}}{\text{Total Capital Investment}}
\]

\[
= \frac{15939.16}{5396.80}
\]

Thus the net return for each rupee invested in farming activity is Rs. 2.96 which is approximately three times the money invested and is sufficiently higher than interest rate paid by any financial institution. Therefore, it is advisable for the farmer to invest in his own farm and increase the productivity of the country.
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