

OPTIMAL ALLOCATION OF RESOURCES FOR BANGLADESH AGRICULTURAL UNIVERSITY FARM

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ABSTRACT

A linear programming model was applied to the Agricultural Farm of Bangladesh Agricultural University, Mymensingh to obtain the optimal allocation of resources and thus to maximize profit. The resources used in the LP model were land, draft power, animal power, Irrigation water & fertilizer. The data of three consecutive years of the farm were used to demonstrate the potentiality of optimization and it yields the higher return as compared with the actual return from the farm.

INTRODUCTION

Agriculture is the largest sector of Bangladesh economy. About 85% of the total population of the country are involved directly and indirectly in agriculture. The future economic development of the country will depend largely on the progress made and goal achieved in the agriculture sector during the next decade. The land of our country is highly fertile but production in this sector is not up to the expectation and crisis of food throughout the year retards the development of our country. A better planning for utilization of resources would increase the production in the agricultural farm. A linear programming model can be used to optimal utilization of limited resources for increased production.

A number of crops can be grown in a farm simultaneously. Selection of crops and the area of land that is to be cultivated for a particular crop should be optimized to maximize profit. In Bangladesh, the farmers mainly use bullock as draft power. But it can not fulfil the power demand. Now a days, small tractors are being used in a farm level to supplement the shortage of draft power. Irrigation water, fertilizer and insecticide are also scarce resources and their allocation will increase the production of the farm.

In the developed regions of the world, mathematical model have been applied to the cropping pattern and water management (Hardaker, 1979). Limited studies had been conducted to apply linear programming model to increase agricultural production with the emphasis on its effect on rural employment and income distribution (Biggs, 1974). Several researchers have investigated the consumptive use of ground water and surface water using the technique of dynamic programming and optimal control theory (Buras, 1963; Chowdhury, Hall & Albertson, 1974; Woel, Gardner & Moore, 1980). Panda, Kaushal & Kheper (1983) developed two deterministic linear programming models for the consumptive use of surface & ground water. They applied the models to a canal command area in Punjab for optimal allocation of irrigated land to different crops so that returns from activity are maximized subject to a set of constraints. Rozers & Smith (1970) proposed a linear programming model for cropping pattern and integrated use of ground & surface water in irrigation. They presented a detailed irrigation planning example for a project whose data were similar to those for the Tista Project of the then East Pakistan.

Bari (1985) formulated a linear optimization model to determine the cropping pattern & monthly allocation of irrigation water & then applied to

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Bangladesh condition. He also studied the effect of changes of crop prices and amount of water for irrigation purpose on optimal solution by parametric linear programming. Singh & subbarayan (1986), studied the optimal use of energy inputs on different farm size groups in Meerat district of India. Energy inputs like fertilizer, irrigation water, pesticides including implements, machinery etc. and their optimal allocation on crop farms were studied. Hussain & Enamul (1986) developed a Linear Programming model for optimal cropping patten and irrigation water requirement for the BAU Farm.

The optimal development and management of limited resources is a complex and multifaced problem. A linear programming model is an appropriate technique to handle such type of allocation problem. The agricultural farm of Bangladesh Agricultural University, Mymensingh has been considered to maximize profit in relation to the available resources. Revised simplex algorithm NICELP was used to determine optimal policy. The programme used here was prepared by Prof. Labadie of Colorado State University (Labadie, 1986).

METHODOLOGY

Crop production in a developing region involves allocation of limited resources in maximizing outputs. A linear programming model could be used to allocate the limited resources.

Linear Programming Model

The linear programming model developed by Hussain & Enamul (1986) has been applied for three consecutive year's to the Bangladesh Agricultural University Farm to maximize the profit.

The objective function of the model is (Hussain & Enamul, 1986):

$$\text{Maximize } X_0 = \sum_{ij} [(X_{ij}Y_{ij}P_{ij} + X_{ij}B_{ij}R_{ij}) - (X_{ij}L_{ij}W_{ij} + X_{ij}D_{ij}M_{ij} + X_{ij}I_{ij}N_{ij} + X_{ij}F_{ij}Q_{ij} + X_{ij}H_{ij}K_{ij})]$$

Where,

X_{ij} = amount of land under crop i in season j, ha.

Y_{ij} = yield of crop i in season j, Kg/ha.

P_{ij} = value of crop i in season j, Tk/Kg.

B_{ij} = amount of by-product from crop i in season j, Kg/ha.

R_{ij} = value of by-product of crop i in season j, Tk/Kg.

L_{ij} = no. of labour needed for crop i in season j, man-day.

W_{ij} = wage of labour for crop i in season j, Tk/man-day.

D_{ij} = no. of bullock pair-day / tractor-day for crop i in season j.

M_{ij} = cost of bullock pair-day/ tractor-day for crop i in season j, Tk/bullock pair-day or tractor-day.

I_{ij} = total irrigation water needed for crop i in season j, ha-cm.

N_{ij} = cost of irrigation water for crop i in season j, Tk/ha-cm.

F_{ij} = fertilizer needed for crop i in season j, Kg/ha.

Q_{ij} = cost of fertilizer for crop i in season j, Tk/Kg.

H_{ij} = pesticide needed for crop i in season j, Kg/ha.

K_{ij} = cost of pesticide for crop i in season j, Tk/Kg.

The following constraints are considered in the model (Hussain & Enamul, 1986) :

1. Available land:

$$\sum_{ij} (X_{ij}) \leq X$$

Where, X = total land available for cultivation, ha.

2. Draft power (bullock) :

$$\sum_{ij} (D_{ijm}X_{ij}) \leq (BxP + D_h)$$

Where, D_{ijm} = no of bullock pair-day needed for plowing a hectare of crop i in season j in month m, bullock pair-day/ha.

B = no. of bullock pair available in month m for plowing, bullock-pair.

P = total no of day available for plowing in month m, day

D_h = no. of hired bullock pair-day in month m, bullock- pair (variable).

3. Draft power (Tractor) :

$$\sum_{ijm} (T_{ijm} X_{ij}) \leq (T \times P + T_h)$$

Where, T_{ijm} = no. of tractor-day needed per hactre for crop i in season j in month m .

T = no. of tractor available in month, m .

P = no. of day available for plowing by tractor in month m , day.

T_h = no. of hired tractor-day in month, m (variable).

4. Irrigation Water:

$$\sum_{ijm} (I_{ijm} X_{ij}) \leq I$$

Where, I_{ijm} = total irrigation needed for crop i in season j in month m , ha-cm.

I = total irrigation water available, ha-cm.

5. Fertilizer:

$$\sum_{ij} (F_{ij} X_{ij}) \leq F$$

Where, F_{ij} = amount of fertilizer for crop i in season j , Kg/ha.

F = total amount of fertilizer available for crop i in season j , Kg.

6. Labour:

$$\sum_{ij} (p + t + w + h) X_{ij} \leq (H + H_h)$$

Where, p, t, w & h are the labour co-efficient of plowing, transplanting, weeding and harvesting needed per hactre for crop i in season j . H = total labour -days available in month, m .

H_h = no. of hired labour days in month, m .

RESULTS AND DISCUSSIONS

Production Year 1985-86:

In the production year 1985-86, 10 crops were cultivated and there was a loss of about Tk. 4.39

lakhs. Optimization model predicted that cultivation of 6 crops were more profitable with a net profit of Tk. 1.6 lakhs. Optimization yielded a surplus of draft power in the month of July, September, October of 1985 and January, February, April, May & June of 1986. In other words there was a need of hiring draft power in the rest of the period of the year. There were a large surplus of labour only in the month of April to June 1986. While in the rest of the period of the year there was a need to hire labour.

Production Year 1984-85:

In the production year 1984-85, 10 crops were cultivated and there was a profit of Tk. 0.77 lakhs. Optimization model predicted that cultivation of 4 crops were more profitable with a net return of Tk. 14.6 lakhs. The model also predicted that T Aman (BR-11) has taken 62.4 hectares of land as its profit per unit of land was higher than others. Matikalai was to be cultivated as a multiple cropping system. There was a need of hiring draft power only in the month of July and August of 1984. In the rest of the period of the year the tractor seemed to be remain idle. Total return may be increased by lending these surplus draft power. Throughout the production year there was a mixed pattern of laborer supply and demand.

Production Year 1983-84:

In the production year 1983-84, 10 crops were cultivated and there was a loss of Tk. 0.43 lakhs. Optimization model predicted that cultivation of 7 crops were more profitable with a net profit of Tk. 6.98 lakhs. Optimization yielded that there was a need to hire laborer in some months of the year and also there was a surplus laborer in some other months of the year. There was no deficits of irrigation water & fertilizer during the period.

Sensitivity analysis were performed to study the effects of draft power (tractor & bullock), labour, irrigation & fertilizer constraints. Except irrigation water, no significant effects of these resources were observed.

The LP model used were 41 decision variables & 45 constraints.

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