OPTIMAL CROPPING PATTERN FOR A COMMAND AREA OF DIJKOT DISTRIBUTARY

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A linear programming technique was applied to develop an optimal cropping pattern within the available resources and constraints of the study area at Dijkot distributary. The objective function was to maximize the net returns of the farmers and to make the best use of the available water resources. The proposed optimal cropping pattern eliminated cotton and reduced the cropped area of sugarcane and wheat to 50% and 36% respectively. The area under kharif fodder however remained the same. The adoption of the proposed optimal cropping pattern promised an increase of net returns by 27%.

INTRODUCTION

The present irrigation water supplies in Pakistan are inadequate to meet the consumptive use requirements of the irrigated areas (Ahmad, 1988). As such water stresses prevail round the year, except during the months of July and December *(ISM/CWMP,* 1980). The deficit irrigation water supplies are reflected in the form of low crop yield. A study in respect of the determination of the most profitable cropping pattern would provide guidance to the farmers in the selection and combination of various crops which would maximize their income.

Linear programming is a technique which is more systematic and accurate for determining mathematically the optimal combination of enterprises or inputs so as to maximize the income or minimize the cost within the limits of available resources. The present study aims at developing an optimal cropping pattern which would maximize the net returns of the farmers within the available resources and constraints.

MATERIALS AND METHODS

The study was conducted on the Dijkot distributary command area which is located at the tail reach of Rakh Branch. Three watercourses numbering *30987/L, 45810/R,* and 118500/L, were randomly selected located respectively at the head, middle and tail reaches of Dijkot distributary. A comprehensive interviews of the farmers of the sample watercourses were conducted to collect the information in respect of their existing cropping pattern, cropping intensity and yields of the crops etc. The flow rate of outlets and the tubewells located at the head of each watercourses was measured by cutthroat flume.

Potential evapotranspiration was calculated by Hargreaves and Samani (1985) equation. Crop coefficients were taken from PARC report (1982), to have the net irrigation requirements, which were converted to gross irrigation requirements by considering irrigation efficiencies

(Piracha et al. 1980). The crop yields under optimal conditions for cotton, sugarcane, wheat and maize were taken from the PARC publication 1982, when water requirements of the crops were fulfilled and all other inputs remained the same.

The optimal yields of fodder (rabi and kharif) were taken by personal communication, when water requirements of the crops were met and all others inputs remained the same. The variable costs both for existing and optimal conditions and crops sale prices for cotton, sugarcane, wheat and maize were taken from Chaudhry *et al.* (1991) and for fodder (rabi and kharif) were taken from Chaudhry and Bashir (1986) to calculate net returns (gross margins) of the farms as shown in Table 1. The output of the L.P. model provided optimal cropping pattern as shown in Table 2,3 and 4.

ANALYSIS OF DATA

During this analysis, inter relationship among the various variables was assumed to be linear and the simplex method was employed. The process of solving a linear programming (L.P) model requires a large number of calculations and is therefore, best performed by a computer program. The computer program used was Q.S.B. version 1.5. The acronym stands for quantitative systems for business.

Maximize

$$Z = \Sigma C_j . X_j$$

Subjected to the following constraints:

Water Availability Constraints

$$\Sigma A_{jm} . X_j < = W_m$$

Kharif Land Availability Constraints

$$\Sigma K_j . X_j < = L_k$$

Where j = 1,2,4,6

Rabi Land Availability Constraints

$$\Sigma R_j . X_j < = L_r$$

where j = 2, 3, 5

Maximum Acreage Constraint

$$A_j . X_j < = MAX_j$$

where j = 6

Rabi Fodder Constraint

$$R_j . X_j > = F_r$$

where j = 5

Kharif Capital Constraint

$$\Sigma b_j . X_j < = C_k$$

where j = 1,2,4,6

Rabi Capital Constraint

$$\Sigma b_j . X_j < = C_r$$

where j = 3,5

Non-negativity Constraint

$$X_j > = 0$$

Where,

Z	=	Net income (Rs.)
C_j	=	Gross margins from j-th crop (activity) (Rs./ha)
j	=	1, Cotton
j	=	2, Sugarcane
j	=	3, Wheat
j	=	4, Maize
j	=	5, Rabi fodder
j	=	6, Kharif fodder

Table 1. Gross Margins for Existing and Optimal Cropping Patterns (Rs.jha)

Crop	Existing			Optimal		
	Gross Returns	Variable Cost	Gross Margins	Gross Returns	Variable Cost	Gross Margins
Collon	6390.00	3660.00	2730.00	nw.oo	3660.00	4109.00
Sugarcane	9855.00	4606.00	5249.00	20705.00	4919.00	15786.00
Wheat	4246.00	2322.00	1924.00	5385.00	2410.00	2975.00
Maize	2975.00	1122.00	1853.00	3600.00	1171,00	2429.00
Rabi Fodder	3065.00	1254.00	1811,00	3673.00	1254.00	2419.00
Kharif Fodder	2502.00	935.00	1567.00	2964.00	935.00	2029.00

Table 2 Existing and Optimal Cropping Pattern in % of CCA (Watercourse number 30987jL)

Crop	Kharif Season			Crop	Rabi Season		
	Existing	Optimal	Deviation		Existing	Optimal	Deviation
Collon	7.23	0.00	-100.00	Wheat	45.'J3	33,05	-29.04
Maize	10,50	14,70	40.00	Sugarcanc	26.53	13,17	-50.36
Sugarcane	26.53	13,17	-50.36	RalJi Fodder	17,58	17.58	0.00
Kharif Fodder	21,16	21,16	0.00	-	-	-	
Total	65,42	49.03	-25.05	Total	'JO.lJ4	63.80	-29,14

Table 3 Existing and Optimal Cropping Pattern in % of CCA (Watercourse number 4510jR)

Crop	Kharif Season			Crop	Rabi Season		
	Existing	Optimal	Deviation (%)		Existing	Optimal	Deviation (%)
Collon	7.71	0.00	-100.00	Wheat	45.88	28.79	-37.25
Maize	7,51	10,51	40.00	Sugarcanc	27.29	13,24	-51,48
Sug;ucane	27.29	13.24	-51,48	RalJi Foddcr	1(,.82	23.54	40.00
Kharif fodder	20.09	20.09	0.00	-	-	-	
Total	62.60	43.84	-29.97	Total	89.')<)	65,57	-27.14

Table 4 Existing and Optimal Cropping Pattern in % of CCA (Watercourse number 118500jL)

Crop	Kharif Season			Crop	Rabi Season		
	Existing	Optimal	Deviation (%)		Existing	Optimal	Deviation (%)
COllon	4.31	0.00	-100.00	Wheat	46.24	25.81	-44.18
Maize	7.51	10.51	40.00	Sugarcane	28.33	13.66	-51.58
Sugarcane	28.33	13.66	-51.78	Rahi Fodder	13.86	19.40	40.00
Kharif Fodder	16.11	16.11	0.00	-	-	-	
Total	56.26	40.28	-28.40	Total	88.43	58.87	-33.43

Xj	=	Level of j-th crop (ha)
Ajm	=	Amount of water required for the j-th crop during the moth month (cm).
m	=	1, January, m = 2, February ....m = 12, December
Wm	=	Availability of water in the moth month (ha-ern)
K_j	=	Land required per unit of j. th crop during kharif season
Lk	=	Land available during kharif season (ha)
R_j	=	Land required per unit of j-th crop during rabi season
L_r	=	Land available for rabi crop (ha)
Aj	=	Land required per unit of j-th crop
MAXj	=	Maximum land which can be allocated to j-th crop (ha)
Fk	=	Kharif fodder required (ha)
Fr	=	Rabi fodder required (ha)
b_j	=	Variable cost for j-th crop (Rs.jha)
Ck	=	Total availability of kharif capital (Rs.)
Cr	=	Total availability of rabi capital (Rs.)

The main objectives of the model was to maximize the net returns, subjected to the constraints of land, water, maximum acreage, fodder (kharif & rabi) and working capital (kharif & rabi). The net returns (gross returns less variable cost) per hectare of different crops were calculated. The various items of variable costs were cost of seeds, farm yard manure, fertilizer, plant protection measures, casual hired labor, hired machinery and water charges etc.

RESULTS AND DISCUSSION

The analysis of data with the help of L.P model developed an optimal cropping pattern both for Kharif and Rabi crops as shown in Tables 2, 3 and 4: The optimal cropping pallern proposed for all the watercourses suggests complete elimination of cotton crop which was most probably due to higher variable cost of the cotton crop in the form of pesticides etc. The kharif fodder remained the same because they were probably already growing at optimal levels and were giving higher net returns. The model also suggested decrease in the cropped area of sugarcane and wheat because of the shortage in water supplies. This may also be the reason for lower yields of the said crops under existing cropping pattern. The model suggested about 40% increase in the area of maize crop probably due to the water availability during that growth period.

The optimal cropping pattern developed was based on the idea that water requirements of the corps should be completely fulfilled by reducing the cropping intensity in the study area, while keeping all other inputs such as fertilizer and plant protection measures at the same level as under existing cropping pattern, Reduction in the cropping intensity made water available in, sufficient quantity as was needed optimally for crops and thus crop yield was increased. The increase in crop yields resulted in the increase of net rct urns of the farmers as shown in Table 5. The increase in the net returns was found to be 27% (Maqsood, 1992) by adopting optimal cropping pattern.

Table S. Net return per watercourse from existing and optimal pattern (rs.)

Sr. No.	Water Course No.	Location	Net Return		Deviation (%)
			Existing	Optimal	
1	30987/L	Head	115304.00	14S6925.00	28.82
2	4581O/R	Middle	9k9423.30	1258865.00	27.23
3	118500/L	Tail	S87708.80	112087.00	26.74

The following conclusions are made based on the results of the study:

1. The optimal solution suggested complete elimination of cotton crop, 40 percent increase in the acreage of maize eorp, 50% reduction in the acreage of sugarcane crop and no change in the acreage of Kharif fodder on all the three selected watercourses. Further, the optimal solution suggested 28%, 37% and 44 % reduction in the acreage a wheat crop on watercourses numberings 30987/L, 4581O/R and 118500/L respectively. The optimal solution also suggested 40% increase in the acreage of rabi fodder on watercourses numberings 4581O/R and llk500/L.

2. The adoption of optimal cropping pattern showed an increase of 27% in the net returns of the farms in the study area.

3. Annual canal closure takes place at the time of maximum demand of water for rabi crops, causing a great stress to these crops.

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