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DEVELOPMENT OF MULTI OBJECTIVE TECHNIQUES

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Abstract

In India and abroad, the commonly used decision modeling in real life rests on the assumption that the decision maker seeks to optimize a well-defined single objective using traditional mathematics programming approach. A farmer may be interested in maximizing his cash income, with certain emphasis on risk minimization. On the other at county level especially in a developing country a planner may aspire for a plan while maximizes food grains production and also to some extent considers employment maximization etc as the goals. Keeping in view the objectives of the study, state-wise secondary data on different variables for the period 1980-81 to 2014-15 were collected from Statistical Abstracts of Punjab, Fertilizer Statistics, Agricultural Statistics at a glance and the reports of the Commission for Agricultural Costs and Prices, published by Ministry of Agriculture By taking its deviations of observed Yt from its estimated value we got the error or the risk coefficients for each year for each crop. These risk coefficients were taken in the matrix formulation in the MOTAD format suggested by Hazell (1971 a and b). To give a meaningful explanation to the level of risk, total mean absolute deviations in gross returns were derived as under:

Min A = 1/S Σ| (chj-gj) xj |

Where A is the minimum average absolute deviation defined as the mean over (h=1………s) years, of the sum of the deviations of

gross returns (chj) from the trend in gross returns (gj) multiplied by activity levels x j (j = 1………n). Where A is an unbiased

estimator of the population mean absolute income deviation

Where A = estimated mean absolute deviation

S = no. of years

chj = gross returns of the jth activity in hth year

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gj = sample mean of gross returns of jth activity

x j = activity level

This was minimized subject to the following constraints:

Σaij xj ≤ bi (for all i = 1…………m, j =1……..n)

Total activity requirements for the i th constraint, the sum of the unit activity requirements aij for the constraint i times the activity levels 'xj'do not exceed the level of the i th constraint bi for all 'i' and x j 0 all activity levels are non negative.

Where a ij = per unit technical requirement for the jth activity of

the ith resource.
bi = the ith resource constraint level

m = no. of constraints

n = no. of activities

Keywords: Multi Objective Linear Programming Techniques.

I. Introduction

In India and abroad, the commonly used decision modeling in real life rests on the assumption that the decision maker seeks to optimize a well-defined single objective using traditional mathematical programming approach. Usually taking farming as a business enterprise, a centrist farmer will always like to allocate all the resources available at his farm in such a way that he may get maximum possible income. However in reality this is not the case as the decision maker is usually seeking an optimal compromise amongst several objectives, many of which may be in conflict. For example a farmer may be interested in maximizing his cash income, with certain emphasis on risk minimization. On the other at county level especially in a developing country a planner may aspire for a plan while maximizes food grains production and also to some extent considers employment maximization etc as the goals. So in the real world the decision makers are engaged in pursuit of several objectives and the traditional paradigm is in fact inadequate for dealing with such situations.
The application of multiple objective planning techniques in farm planning will undoubtedly lend realism to the exercise in farm planning because of the great potential of multiple objective programming in handling farm planning problems more comprehensively and its acceptability for developing the optimum farm plan is being increasingly recognized . The traditional mathematical programming approach to the modeling of agricultural decisions rests on certain basic assumptions about the situation being modeled and the decision maker himself. One fundamental assumption is that the decision maker (DM) seeks to optimize a well defined single objective. In reality

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this is not the case, as the DM is usually seeking an optimal compromise amongst several objectives, many of which can be in conflict, or trying to achieve satisfying levels of his goals. For instance, a subsistence farmer may be interested in securing adequate food supplies for the family, maximizing cash income, increasing leisure, avoiding risk etc. but not necessarily in that order. Similarly a commercial farmer may wish to maximize gross margin, minimize his indebtedness, acquire more land, reduce fixed costs etc. Two main types of decision-making situations are identified. The first situation deals with problems involving a single decision criterion or objective, while the second one involves several conflicting objectives. It is argued that decision makers are in reality engaged in the pursuit of several objectives and the traditional paradigm is inadequate for dealing with such situations. The present study is undertaken to analyze the food grain production and resource use and to suggest optimum production plans at existing technology for Punjab and Haryana. More specifically the objective of the study is to develop the optimum production plans

II. Review of Literature

Pant and Pandey (1999) made attempt to delineate the major environmental protection objectives for the hill agriculture, and to develop a multi-objective farm planning model for minimization of environmental problems while maintaining the present level of foodgrain production and farm income. For the purpose, a representative hill district of Dhanding in Nepal was selected for obtaining the requisite data and other information. In all optimal plans, negative deviations from the economic goal levels (i.e. Targets for food grains production, milk production and cash farm income) and positive deviations from environmental goal levels (i.e. targets for soil erosion, cattle grazing, forest fodder and use of nitrogen, phosphorus and pesticides) are minimized. The optimum plan also suggests the substitutions of buffaloes for cows for milk production compared to the cows, the buffaloes have higher milk productivity, with more percentage of fat in milk. Provided, yet they did not seem to be adequately utilized by the villagers.

Malhan (1996) generated the compromise farm plans for different farm size categories for different zones in the Punjab state considering different objectives i.e. maximization of cash income and labour employment, minimization of working capital borrowing and labour use variability and also minimization of risk by using multi-objective programming techniques. he suggested different compromise farm plans on different farm situations which were preferred than the existing plan of each objective.

Domingo and Rehman (1988) presented an approach synthesizing MOTAD methods with in a compromise programming model to generate 'best compromise' solution which come closest to an ideal point. This approach can be regarded as compromise risk programming method (CRP). The objectives considered were minimizing the sum of absolute values of the total gross margin deviation and maximizing the expected gross margins.

Research Methodology

Keeping in view the objectives of the study, state-wise secondary data on different variables for the period 1980-81 to 2014-15 were collected from Statistical Abstracts of Punjab, Fertilizer Statistics, Agricultural Statistics at a glance and the reports of the Commission for

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Agricultural Costs and Prices, published by Ministry of Agriculture, By taking its deviations of observed Y_t from its estimated value we got the error or the risk coefficients for each year for each crop. These risk coefficients were taken in the matrix formulation in the MOTAD format suggested by Hazell (1971 a and b). To give a meaningful explanation to the level of risk, total mean absolute deviations in gross returns were derived as under:

Min $A = 1/S\ \Sigma \left| (ch_j - g_j)\ x_j \right|$ Where A is the minimum average absolute deviation defined as the mean over (h=1………s) years, of the sum of the deviations of gross returns (ch_j) from the trend in gross returns (g_j) multiplied by activity levels x_j (j = 1………n). Where A is an unbiased estimator of the

population mean absolute income deviation

Where A = estimated mean absolute deviation

S = no. of years

chj = gross returns of the jth activity in hth year

gj = sample mean of gross returns of jth activity

x j = activity level

$\Sigma a_{ij}\ x_j \leq b_i$ (for all i = 1…………m, j =1……..n)

Total activity requirements for the i_{th} constraint, the sum of the unit activity requirements a_{ij} for the constraint i times the activity levels 'x_j'do not exceed the level of the i_{th} constraint bi for all 'i' and x_j 0 all activity levels are non negative.

Where a ij = per unit technical requirement for the jth activity of the ith resource.

bi = the ith resource constraint level

m =no. of constraints

n =no. of activities

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Result and Discussion

Haryana:

In Table 1 the elements of the first four columns and first four rows form the pay off matrix for the Haryana. Here the ideal production plan representing maximum possible returns. 64.82 billion Rs., from a production of 14.18 million tons of good grains, employing of man power of 195.5 million men days labour associated with a risk in returns (mean absolute deviation) 6.238 billion Rs. of risk. The table also shows the anti-ideal plan which involves in 49459 million Rs. of gross returns, 10.6781 million tons of production, 1483 lakh days of labour use and 8555 billion Rs. of risk. The anti-ideal point shows a set of minimum values for the objectives which are to maximized of the maximum values for the objectives which are to be minimized.

By optimizing gross returns or by giving 100 percent weight to this objective we get the elements of first row of the pay off matrix. Here the optimum form plan I suggests to increase the paddy area by 35.13 percent as compare to existing level and a decline of 31.50 percent area under Jowar and 39.28 percent under Tur in irrigated conditions indicating that paddy being the most profitable kharif crop substituted these crops in irrigated condition. In the rabi season, the most profitable crop was wheat which shows 7.41 percent increase while Barley shows the 12.5 percent decline as compare to existing level. Under un-irrigated conditions maize being the most profitable kharif crop showed as increase Rs. 54.16 percent while Jowar, Bajra and Tur shows the decline in area by 33.33 percent, 12.84 percent and 50 percent respectively. In rabi season on un-irrigated lands, wheat showed an increase of 200 percent, considered most profitable rabi crop. The row 2nd of pay off matrix indicating the maximum optimum of grain production suggests that a maximum of 14.1848 tons million of grain production which gave the same plan as plan I i.e. maximizing gross returns, which shows that the crops whose yield level is high are also the most remunerative crops. The optimum plan 3 suggests that a maximum of 1955 lakh days of human labour employment can be achieved by following the form plan I or II indicating that labour intensive crops will also most remunerative/ high grain yielding crops under irrigated conditions under un-irrigated conditions area under gram increased by 15.73 percent while wheat showed 16.66 percent decline as compare to existing cropping pattern in rabi season. The fourth plan of the table shows the plan under least possible risk, it entailed a minimum risk of Rs. 6.238 billions (Rs.) in growing the rabi and kharif crops at their minimum level for example under irrigated condition paddy, wheat, barley, jowar, tur entering at 661, 1820, 28, 50 and 17 thousand hectares level. Under unirrigated conditions maize, jowar, bajra, gram, Tur, wheat and barley entering at 24, 40, 522, 289, 4, 35 and 7 thousand hectare level.

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TABLE 1: PAY OFF MATRIX AND CROPPING PATTERN FOR THE FOUR OBJECTIVES FOR HARYANA, 2014-15

THE OBJECTIVES & THEIR CORRESPONDING VALUES					AREA UNDER FOOD GRAINS (000 HECTARE)											
					IRRIGATED					UNIRRIGATED						
Variables	Gross Returns (billion Rs.)	Production (Million Tons)	Human labour (Million days)	Risk Billion Rs.	Paddy	Wheat	Barley	Jowar	Tur	Maize	Jowar	Bajra	Gram	Tur	Wheat	Barley
Existing pattern	57.02	12.30	172.5	7.24	831	2022	32	73	28	24	60	584	305	8	42	8
Gross Returns (billion Rs.)	64.82 (13.67)	14.18 (15.28)	195.0 (13.04)	8.54 (18.00)	1123 (35.13)	2172 (7.41)	28 (-12.5)	50 (-31.5)	17 (-39.2)	37 (54.16)	40 (-33.3)	509 (-12.8)	262 (-14.0)	4 (-50.0)	126 (200.0)	7 (-12.5)
Production (Million Tons)	64.82 (13.67)	14.18 (15.28)	195.0 (13.04)	8.54 (18.00)	1123 (35.13)	2172 (7.41)	28 (-12.5)	50 (-31.5)	17 (-39.2)	37 (54.16)	40 (-33.3)	509 (-12.8)	262 (-14.0)	4 (-50.0)	126 (200.0)	7 (-12.5)

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Human labour (Million days)	64.45 (13.03)	14.06 (14.30)	195.5 (13.33)	8.55 (18.14)	1123 (35.13)	2172 (7.41)	28 (-12.5)	50 (-31.5)	17 (-39.2)	37 (54.16)	40 (-33.3)	509 (-12.8)	353 (15.73)	4 (50.0)	35 (-16.6)	7 (-12.5)
Risk (Billion Rs.)	49.45 (-13.2)	10.67 (-13.2)	148.3 (-14.02)	6.23 (-13.8)	661 (-20.4)	1820 (-9.9)	28 (-12.5)	50 (-31.5)	17 (-39.2)	24 (0.0)	40 (-33.3)	522 (-10.6)	289 (-5.24)	4 (-50.0)	35 (-16.2)	7 (-12.5)

Note : Figure in parentheses represents percentage change over existing level

TABLE 2 RESOURCE USE PATTERN IN PAY OF MATRIX FOR THE FOUR OBJECTIVES FOR HARYANA, 2014-15

PARTICULARS	EXISTING USE	PLANS			
		1	2	3	4
Kharif fertilizer (000 tons)	161.776	207.129 (28.03)	207.129 (28.03)	207.129 (28.03)	1305.29 (-19.31)
Rabi fertilizer (000 tons)	363.711	384.205 (5.63)	384.205 (5.63)	376.414 (3.49)	316.296 (-13.03)
Kharif Capital (billion Rs.)	9.046	11.255 (24.41)	11.255 (24.41)	11.255 (24.41)	7.329 (-18.78)

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Rabi capital (billion Rs.)	16.011	17.325 (8.20)	17.325 (8.20)	17.166 (7.21)	14.418 (-9.94)
Total human labour (million man days)	172.5	195.0 (13.04)	195.0 (13.04)	195.5 (13.33)	148.3 (-14.02)

Note : Figure in parentheses represents percentage change over existing level

The resource use pattern in pay off matrix shows (table 2) that consumption of kharif fertilizer increased by 28.03 percent in first three plan as compare to existing level while kharif capital shows the 24.41 percent of increase Rabi fertilizer increased 5.63 percent in first 2 plans and 3.49 percent in IIIrd optimum plan while Rabi capital will be increased by 8.20 percent in Ist two plan and 7.21 in 3rd plan. The labour requirement increased by 13.04 percent in plan I and II and 13.33 percent in plan III as compared to the existing plan.

Punjab:

In table 3 the elements of the first four rows and columns forms the pay off matrix for the Punjab. Here the ideal production plan representing maximum possible returns of 128.79 billion Rs, a maximum grain production 28.95 million tons, a maximum labour use 294.8 million man days and the minimum possible risk in returns (mean absolute deviation) 9.37 billion Rs., under the present resource constrains was possible employing resources optimally. The table also shows the anti-ideal plan for gross return, 108.67 billion Rs. under the ideal plan for risk similarly the anti-ideal 23.84 million tons of grain production and 252.2 million days of labour use. The anti-ideal point for risk was Rs. 11.56 million under the maximum of grain production or gross returns plans.

By optimizing gross returns or by giving 100 percent weight to this objective we get the elements of first row of the pay off matrix. Here the optimum farm plan I shows the increase in gross returns by 11.11 percent, grain production 11.33 percent, labour use 13.31 percent and in risk 10.39 percent as compare to existing level by following the increase in paddy area by 20.95 percent as compare to existing level in irrigated conditions also indicating that paddy was the most profitable cultivated kharif crop in Punjab. In the rabi season, the most profitable crop was wheat which shows the 7.38 percent increase, while Barley shows 16.21 percent decline as compare to existing level. While gram enters at minimum level. Under unirrigated conditions maize being the most profitable kharif crop showed an increase of 13.04 percent while Tur’s area declined by 27.27 percent as compare to existing level. Moong Bajra and mash entered in plan at their minima level. In rabi season the area under manar increased from 5 thousand hectare to 34 thousand hectare while gram shows no changes as compare to existing level. The row 2nd of pay oft matrix indicating the maximum optimum of grain production at 28.95 million tons of grain production which gave the same plan as plan-I i.e. maximizing gross returns which shows that crops whom yield level were high was also the most remunerative crops. The optimum plan 3 suggests that a maximum of 294.8 million man days of human labour

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employment can be achieved showing the 13.42 percent increase in employment as compare to existing labour use by following the farm plan I or II under irrigated conditions indicating that labour intensive crops were also the most remunerative / high grain yielding crops. Under unirrigated conditions area under gram increased from 6 thousand hectare to 35 thousand hectares as compare to existing level, indicating also the labour intensive gram as compare to massar. The fourth plan of the table shows the plan under least possible risk, it entailed a minimum risk of Rs. 9.37 billion in growing the rabi and kharif crops at their minima level for example under irrigated conditions wheat, paddy, Barlay, Maize, gram, and Moong entering at 2812, 2024, 31, 93 and 95 thousand hectare level and under unirrigated conditions moong, maize gram, Bajra, mash, tur and manar entering at 20, 61, 35, 6, 25 and 5 thousand hectare level. The resources use pattern in pay off matrix shows (table 4) that consumption of rabi fertilizer would increase by 7.28 percent in plan I, II and

III as compare to existing level while kharif fertilizer increased by 15.60 percent in plan I, II and III and 1.92 percent in plan iv. Rabi capital increased 7.34 percent in plan I and II and 7.34 percent in plan IIIrd while kharif capital will be increased by 15.73 percent in plan I, II and III as compare to existing level. The labour requirement increased by 13.37 percent in plan I and 13.42 present plan III as compare to existing labour use.

TABLE 3: PAY OFF MATRIX AND CROPPING PATTERN FOR THE FOUR OBJECTIVES FOR PUNJAB, 2014-15

THE OBJECTIVES & THEIR CORRESPONDING VALUES					AREA UNDER FOOD GRAINS (000 HECTARE)												
					IRRIGATED						UNIRRIGATED						
Variables	Gross Returns (billion Rs.)	Production (Million Tons)	Human labour (Million days)	Risk (Billion Rs.)	Wheat	Paddy	Barley	Maize	Gram	Moong	Moong	Maize	Gram	Bajra	Mash	Tur	Massar
Existing	115.91	26.00	259.9	10.47	3102	2281	37	96	7	30	20	69	6	8	6	11	5

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pattern																	
Gross Returns (billion Rs.)	128.79 (11.11)	28.95 (11.33)	294.5 (13.31)	11.56 (10.39)	3331 (7.38)	2759 (20.95)	31 (-16.21)	93 (-3.12)	7 (0.0)	30 (0.0)	20 (0.0)	78 (13.04)	6 (0.0)	8 (0.0)	6 (0.0)	8 (-27.27)	34 (580.0)
Production (Million Tons)	128.79 (11.11)	28.95 (11.33)	294.5 (13.31)	11.56 (10.39)	3331 (7.38)	2759 (20.95)	31 (-16.21)	93 (-3.12)	7 (0.0)	30 (0.0)	20 (0.0)	78 (13.04)	6 (0.0)	8 (0.0)	6 (0.0)	8 (-27.27)	34 (580.0)
Human labour (Million days)	128.73 (11.06)	28.94 (11.30)	294.8 (13.42)	11.48 (9.59)	3331 (7.38)	2759 (20.95)	31 (-16.21)	93 (-3.12)	7 (0.0)	30 (0.0)	20 (0.0)	78 (13.04)	35 (483.3)	8 (0.0)	6 (0.0)	8 (-27.27)	5 (0.0)
Risk (Billion Rs.)	108.67 (-	23.84 (-8.31)	252.2 (-2.96)	9.37 (-10.5)	2812 (-9.34	2024 (-11.2	31 (-16.2	93 (-3.1	7 (0.0)	95 (216.66)	20 (0.0)	61 (-11.5	35 (483.3)	8 (0.0)	6 (0.0)	25 (127.27)	5 (0.0)

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	6.24)				)	6)	1)	2)				9)					

Note : Figure in parentheses represents percentage change over existing level

TABLE 4 RESOURCE USE PATTERN IN PAY OF MATRIX FOR THE FOUR OBJECTIVES FOR PUNJAB, 2014-15

PARTICULARS	EXISTING USE	PLANS			
		1	2	3	4
Kharif fertilizer (000 tons)	660.541	708.674 (7.28)	708.674 (7.28)	708.674 (7.28)	598.646 (-9.37)
Rabi fertilizer (000 tons)	397.654	459.702 (15.60)	459.702 (15.60)	459.702 (15.60)	405.307 (1.92)
Kharif Capital (billion Rs.)	26.495	28.470 (7.45)	28.470 (7.45)	28.442 (7.34)	24.044 (-9.25)
Rabi capital (billion Rs.)	20.227	23.409 (15.73)	23.409 (15.73)	23.409 (15.73)	20.097 (-0.64)
Total human labour (million man days)	259.9	294.5 (13.31)	294.5 (13.31)	294.8 (13.42)	252.2 (-2.96)

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Note : Figure in parentheses represents percentage change over existing level

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