INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X

Impact factor: 4.295

(Volume3, Issue1)

Available online at: www.Ijariit.com

An Application of Multi Objective Programming Techniques: A Case Study Center of India (Uttar Pradesh, Madhya Pradesh, Rajasthan)

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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 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 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 minimisation 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.

III. 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 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 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:

$\text{Min } A = 1/S \, \Sigma | (ch_j - g_j) \, x_j |$

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
ch_j = gross returns of the jth activity in hth year
g_j = sample mean of gross returns of jth activity
x_j = activity level

This was minimized subject to the following constraints:

$\Sigma a_{ij} x_j \leq b_i$ (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.
b_i = the i_{th} resource constraint level
m = no. of constraints
n = no. of activities

IV. RESULT AND DISCUSSION

MADHYA PRADESH

In table 1 the elements of the first four rows and columns form the pay off matrix for Madhya Pradesh. Here the ideal production plan representing maximum possible returns 93.486 billion Rs. a maximum possible grain production 19.74 million tons, maximum of man power employment 949.1 million man days and minimum possible risk in return (mean absolute deviation) 23.64 billion Rs. under the present resource constraints was possible employing resource optimally. The table also shows the anti-ideal plan for gross returns 71.80 billion Rs. under the ideal plan for risk. similarly anti-ideal 14.39 million tons of grain production, 782.5 million days of labour use. The anti-ideal point for risk was 34.09 billion Rs. under the maximum human labour employment plan.

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 17.61 percent, in grain production 19.98 percent, in labour use 17.36 percent and in risk 17.49 percent as compare to existing level by following the increase in paddy area by 12.17 percent as compare to existing level under irrigated conditions. This shows that the paddy was the most profitable cultivated kharif crop in Madhya Pradesh. In the rabi season, wheat shows 7.70 percent increase in area while gram and barley shows a decline of nearby 17.25 percent and 6.89 percent respectively as compare to existing level. under unirrigated conditions bajra and maize shows the increase of 57.04 and 44.83 percent, whereas tur and paddy shows the increase of 44.04 percent and 13.66 percent, while the mash crop shows the decline of 10.23 percent in area. In rabi season und conditions, wheat was the most profitable rabi crop which shows an increase of 40.71 percent while gram and barley shows decline of 17.22 and 6.45 percent as compare to the existing level. The row 2nd of pay off matrix indicating the maximum optimum of grain production at 19.74 million tons of grain production (shows 20.35 percent increase as compare to existing level) by following the same plan as plan I under irrigated conditions and under unirrigated land in kharif season, jowar shows the increment of 141.65 percent in area. While paddy shows the decline in area by 10.53 percent. The optimum plan 3 suggests that a maximum of 949.1 million days of human labour employment can be achieved showing the 17.41 percent increase in employment as compare to existing labour use by following the farm plan I and II under irrigated conditions indicating that labour intensive crops were also high grain yielding crops. Under unirrigated land, area under Tur and paddy increased by 44.04 and 14.45 percent while the area under Bajra show an increment of 33.80 percent as compare to existing level. The fourth plan of table shows the plan under least possible risk, it entailed a minimum risk of Rs. 23.64 billion in growing rabi and kharif crops at their minimum level for example under irrigated conditions paddy, wheat, barley and gram entering at 1115, 2276, 27 and 662 thousand hectare level and under unirrigated conditions paddy, wheat, jowar, bajra, maize, barley, grain, tur, moong and mash entering at 3338, 926, 843, 135, 847, 58, 1475, 361, 118 and 500 thousand hectare level.

The resource use pattern in pay off matrix shows (table 2) that consumption of kharif fertilizer would increase by 14.43 percent, 11.58 percent, 14.59 percent and 0.99 percent in plan I, II, III and IV respectively, while the consumption of rabi fertilizer would increase by 40.19 percent and declined by 14.93 percent in plan I, II and III and plan IV as compare to existing resource use pattern. The use of kharif capital will be increased by 15.57 percent, 12.84 percent, 16.00 percent and 8.37 percent in plan I, II, III and IV respectively while rabi capital shows the increment of 16.52 percent in plan I, II, III and declined by 22.21 percent in plan IV. The labour requirement increased by 17.36 percent, 15.18 percent, 17.41 percent and declined by 3.19 percent in optimizing plan I, II, III and IV respectively as compare to existing labour use.

Madhya Pradesh. TABLE 1 : PAY OFF MATRIX AND CROPPING PATTERN FOR THE FOUR OBJECTIVES FOR MADHYA PRADESH, 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	Gram	Paddy	Wheat	Jowar	Bajra	Maize	Barley	Gram	Tur	Moong	Mash
Existing pattern	79.46	16.40	808.3	28.96	1248	3167	29	800	4178	1422	833	142	861	62	1782	361	118	557
Gross Returns (billion Rs.)	93.48 (17.61)	19.68 (19.98)	948.7 (17.36)	34.03 (17.49)	1400 (12.17)	3411 (7.70)	27 (-6.8)	662 (-17.2)	4749 (13.66)	2001 (40.71)	843 (1.2)	223 (57.04)	1247 (44.83)	58 (-6.45)	1475 (-17.2)	520 (44.04)	118 (0.0)	500 (10.23)
Production (Million Tons)	92.61 (16.51)	19.74 (20.35)	931.0 (15.18)	32.61 (12.56)	1400 (12.17)	3411 (7.70)	27 (-6.8)	662 (-17.2)	3738 (-10.5)	2001 (40.71)	2013 (141.6)	223 (57.04)	1247 (44.83)	58 (-6.45)	1475 (-17.2)	361 (0.0)	118 (0.0)	500 (10.23)
Human labour (Million days)	93.46 (17.59)	19.67 (19.93)	949.1 (17.41)	34.09 (17.69)	1400 (12.17)	3411 (7.70)	27 (-6.8)	662 (-17.2)	4782 (14.45)	2001 (40.71)	843 (1.20)	190 (33.80)	1247 (44.83)	58 (-6.45)	1475 (-17.2)	520 (44.04)	118 (0.0)	500 (10.23)
Risk (Billion Rs.)	71.80 (-9.65)	14.39 (-12.23)	782.5 (-3.19)	23.64 (-18.3)	1115 (-10.6)	2276 (-28.1)	27 (-6.8)	662 (-17.2)	3338 (-20.1)	926 (-34.8)	843 (1.20)	135 (-4.9)	847 (-1.6)	58 (-6.45)	1475 (-17.2)	361 (0.0)	118 (0.0)	500 (10.23)

Note : Figure in parentheses represents percentage change over existing level

TABLE 2 RESOURCE USE PATTERN IN PAY OF MATRIX FOR THE FOUR OBCTIVES FOR MADHYA PRADESH, 2014-15

PARTICULARS	EXISTING USE	PLANS			
		1	2	3	4
Kharif fertilizer (000 tons)	442.38	506.24 (14.43)	493.68 (11.58)	506.94 (14.59)	446.77 (0.99)
Rabi fertilizer (000 tons)	371.93	521.43 (40.19)	521.43 (40.19)	521.43 (40.19)	316.38 (-14.93)
Kharif Capital (billion Rs.)	31.37	36.26 (15.57)	35.40 (12.84)	36.29 (16.0)	33.99 (8.37)
Rabi capital (billion Rs.)	29.55	34.43 (16.52)	34.43 (16.52)	34.43 (16.52)	22.99 (-22.21)
Total human labour (million man days)	808.3	948.7 (17.36)	931.0 (15.18)	949.1 (17.41)	782.5 (-3.19)

Note: Figure in parentheses represents percentage change over existing level.

RAJASTHAN

In table 3 the elements of the first four rows and columns form the pay off matrix for the Rajasthan. There the ideal production plan representing maximum possible returns 62.982 billion Rs., a maximum possible grain production 13.828 million tons, maximum of man power employment 634.8 million man days and minimum possible risk in returns (mean absolute deviation) 10.383 billion Rs., under the present resource constraints was possible employing resources optimally. The table also shows the anti-ideal plan for gross returns 41.896 billion Rs. Under the ideal plan for risk. Similarly anti-ideal 9.0097 million tons of grain production, 474.9 million days of labour use. The anti-ideal point for risk was 14.977 billion Rs. Under the maximum gross returns plan.

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 5.47 percent, in grain production 5.32 percent, in labour use 5.54 percent and in risk 5.82 percent as compare to existing level by following the increase in paddy and Tur area by 126.47 percent and 371.42 percent while maize entered at minimum level as compare to existing level under irrigated conditions. This shows that the paddy was the most profitable cultivated kharif crops in Rajasthan. In the rabi season, the most profitable crop was barley which shows the increase of 187.5 percent. Gram shows the decline of 21.44 percent as compare to existing level. Under unirrigated conditions, Tur and Mash shows the increase of area from 39 and 208 thousand hectare to 360 and 631 thousand hectare, while paddy and moong shows the decline of 27.08 percent and 45.64 percent. Bajra and maize shows the decline of 9.14 percent and 6.56 percent in area respectively.

In rabi season, under unirrigated conditions, wheat shows the increase of 352.5 percent in area. Barley shows the increase of 263.38 percent while gram shows the decline of 28.60 percent respectively. The row 2nd of pay off matrix indicating the maximum optimum of grain production at 13.838 million tons of grain production (shows the 9.96 percent increase as compare to existing level) by following the same kharif plan as plan I under irrigated conditions and in rabi season, barley shows the increase of 347.47 percent while gram shows the decline of 53.31 percent in area as compare to existing pattern which indicating the barley is more yielding crop, under irrigated conditions. Under irrigated land, in kharif season, maize crop shows the increase of 107.41 percent while Tur shows the decline of 57.14 percent respectively. Under unirrigated conditions, in kharif season, paddy and maize shows the increase of 60.14 percent and 14.60 percent. While mash and Bajra shows the decline of 29.32 percent and 4.89 percent respectively.

The optimum plan 3 suggests that a maximum of 634.8 million days of human labour employment can be achieved showing the 13.60 percent increase in employment as compare to existing labour use by following the same farm plan II for rabi season under irrigated conditions indicating that labour intensive crops were also high grain yielding crops. Under irrigated conditions, in kharif season maize crop shows the increase of 482.14 percent while paddy shows the decline of 27.94 percent under unirrigated land, in kharif season, jowar shows the increase of 111.94 percent while paddy and Tur shows the decline of 27.08 and 58.97 percent respectively. The fourth plan of the table shows the plan under least possible risk. It entailed a minimum risk of Rs. 10.383 billion in growing rabi and kharif crops at their minimum level for example under irrigated conditions paddy, wheat, barley, gram, tur and maize entering at 49, 1941, 129, 134, 3 and 28 thousand hectare level and under unirrigated conditions, paddy, wheat, jowar, Bajra, maize, gram, tur, mash, moong and barley entering at 70, 92, 1201, 4272, 883, 895, 16, 147, 386 and 48 thousand hectare level.

The resource use pattern in pay off matrix shows (table 4) that consumption of kharif fertilizer would increased by 3.10 percent, 18.52 percent, 28.36 percent and 14.81 percent in plan I, II, III and IV respectively. While the consumption of rabi fertilizer would increased by 7.15 percent and 14.13 percent in plan I, plan II and III, respectively as compare to existing resource use pattern. The use of kharif capital will be increased by 14.91 percent, 13.11 percent, 12.65 percent and 12.58 percent in plan I, II, III and IV respectively while rabi capital shows the increment of 7.02 percent and 11.10 percent in plan I, plan II and III, respectively. The labour requirement increased by 5.54 percent, 11.70 percent and 13.60 percent in plan I, II, III and a decline by 15.01 percent in plan IV respectively as compare to existing labour use.

Rajasthan:

TABLE 3: PAY OFF MATRIX AND CROPPING PATTERN FOR THE FOUR OBJECTIVES FOR RAJASTHAN, 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	Gram	Tur	Maize	Paddy	Wheat	Jowar	Bajra	Maize	Gram	Tur	Mash	Moong	Barley
Existing pattern	59.71	12.57	558.8	14.15	68	2518	192	287	7	28	96	160	561	4702	945	1926	39	208	631	71
Gross Returns (billion Rs.)	62.98 (5.47)	13.24 (5.32)	589.8 (5.54)	14.97 (5.82)	154 (126.4)	1978 (-21.4)	552 (187.5)	493 (71.7)	33 (371.4)	28 (0.0)	70 (-27.08)	724 (352.5)	561 (0.0)	4272 (-9.1)	883 (-6.56)	1375 (-28.60)	360 (823.0)	631 (203.36)	343 (-45.6)	258 (263.3)
Production (Million Tons)	61.66 (3.25)	13.82 (9.96)	624.2 (11.70)	14.77 (4.36)	154 (126.4)	1978 (-21.4)	911 (374.47)	134 (-53.3)	3 (-57.1)	58 (107.4)	154 (60.41)	724 (352.5)	561 (0.0)	4472 (-4.8)	1083 (14.60)	1375 (-28.60)	360 (823.0)	147 (-29.32)	343 (-45.6)	258 (263.3)
Human labour (Million days)	59.88 (0.29)	13.69 (8.87)	634.8 (13.60)	14.60 (3.17)	49 (-27.94)	1978 (-21.4)	911 (374.47)	134 (-53.3)	3 (-57.1)	163 (482.1)	70 (-27.08)	724 (352.5)	1189 (111.9)	4272 (-9.1)	1083 (14.60)	1375 (-28.60)	16 (-58.9)	147 (-29.32)	343 (-45.6)	258 (263.3)
Risk Billion Rs.	41.89 (-29.83)	9.00 (-28.35)	474.9 (-15.01)	10.38 (-26.63)	49 (-27.94)	1441 (-42.77)	129 (-32.81)	134 (-53.3)	3 (-57.1)	28 (0.0)	70 (-27.08)	92 (-42.5)	1201 (114.08)	4272 (-9.1)	883 (-6.56)	895 (-53.53)	16 (-58.9)	147 (-29.32)	386 (-38.82)	48 (-32.39)

Note : Figure in parentheses represents percentage change over existing level.

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

PARTICULARS	EXISTING USE	PLANS			
		1	2	3	4
Kharif fertilizer (000 tons)	148.114	152.712 (3.10)	175.554 (18.52)	190.124 (28.36)	170.061 (14.81)
Rabi fertilizer (000 tons)	272.417	291.897 (7.15)	310.924 (14.13)	310.924 (14.13)	156.625 (-42.50)
Kharif Capital (billion Rs.)	14.886	17.106 (14.91)	16.838 (13.11)	16.770 (12.65)	16.759 (12.58)
Rabi capital (billion Rs.)	22.849	24.454 (7.02)	25.387 (11.10)	25.387 (11.10)	12.761 (-44.15)
Total human labour (million man days)	558.8	589.5 (5.54)	624.2 (11.70)	634.8 (13.60)	474.9 (-15.01)

Note : Figure in parentheses represents percentage change over existing level.

UTTAR PRADESH

In Table 5 the elements of the first four columns and first four rows farms the pay off matrix for the Uttar Pradesh. Here the ideal production plan representing maximum possible returns of 210.171 billion Rs, a maximum possible production of 46.88 million tons of food grains, maximum of man power employment of 111.86 million man days and the minimum possible risk in returns (mean absolute deviation) 29.034 billion Rs. Under the present resume constraints was possible employing resources optimally. The table also shows the anti-ideal plan gross return of for 155.146 billion Rs. under the ideal plan for risk. Similarly anti ideal 34.42 million tons of grain production, 8349 lakh days of labour use and 40.118 million Rs of risk. The anti-ideal point shows a set of minimum values for the objectives which are to maximized and 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 farm plan I suggests to increases the paddy area by 21.14 present wheat area by 10.00 percent and Barley area by 95.65 percent as compare to existing level and a decline of 17.92 percent area under maize, 4.76 percent area under Tur and 9.20 percent area under gram in irrigated conditions, indicating that paddy and wheat being the most profitable kharif and rabi crops substituted these crops in irrigated conditions. Under unirrigated conditions paddy also being the most profitable kharif crop showed an increase of 17.76 percent while jowar, Bajra and Maize shows the decline in area by 13.54 percent, 14.84 percent and 14.22 percent respectively than existing level. In rabi season, on unirrigated lands, wheat showed an increase of 85.28 percent, followed by Barley and gram which shows the increment of 56.41 percent and 21.60 percent respectively. The row 2 of pay off matrix indicating the maximum optimum of grain production suggests that a maximum of 46.88 million tons of grain production by following same plan I under irrigated conditions but under unirrigated conditions area under Barley increased by 184.6 percent while gram showed 6.11 percent decline as compare to existing level in rabi season. The optimum plan 3 suggest that as maximum of 11186 lakh days of human labour employment can be achieved by following the same plan as plan II i.e. maximizing grain production. Which shows that the crops whose yield level were high will also the more labour intensive crops. The fourth plan of the table shows the plan under least possible risk, it entailed a risk level of Rs. 29034 million in growing the rabi and kharif crops at their minimum desired level for example under irrigated condition, wheat, paddy, maize, Barley, tur and gram entering at 7073, 2869, 261, 170, 60 and 148 thousand hect. level and under unirrigated conditions. Wheat, paddy, jowar, Bajra, maize, barley, tur and gram entering at 544, 1913, 332, 746, 639, 144, 407 and 675 thousand hectares level.

The resource use pattern in pay off matrix shows (table 6) that consumption of rabi fertilizer increased by 13.07 percent in plan I and 13.59 percent in plan II, III while kharif fertilizer showed the increment of 13.63 percent in plan I and 13.63 percent in plan II, III as compare to existing use. The use of rabi capital increased by 13.65 percent in plan I and 13.96 percent in plan II, III while kharif capital increased by 13.68 percent in plan I, II, III as compare to existing use. The labour requirement increased by 15.54 percent in plan I and 15.71 percent in plan II and III as compare in existing labour use.

Uttar Pradesh: TABLE 5 : PAY OFF MATRIX AND CROPPING PATTERN FOR THE FOUR OBJECTIVES FOR UTTAR PRADESH, 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	Maize	Barley	Tur	Gram	Wheat	Paddy	Jowar	Bajra	Maize	Barley	Tur	gram
Existing pattern	183.07	40.60	981.7	35.02	8391	3552	318	184	63	163	761	2111	384	876	745	156	407	719
Gross Returns (billion Rs.)	210.17 (14.80)	46.74 (15.10)	1117 (13.78)	40.11 (14.55)	9230 (10.0)	4303 (21.14)	261 (-17.9)	360 (95.65)	60 (-4.76)	148 (-9.20)	1010 (32.70)	2486 (17.76)	332 (-13.5)	746 (-14.8)	639 (-14.2)	244 (56.41)	407 (0.0)	875 (21.6)
Production (Million Tons)	210.14 (14.78)	46.88 (15.45)	1118.6 (13.94)	39.91 (13.96)	9230 (10.0)	4303 (21.14)	261 (-17.9)	360 (95.65)	60 (-4.76)	148 (-9.20)	1010 (32.70)	2486 (17.76)	332 (-13.5)	746 (-14.8)	639 (-14.2)	444 (184.6)	407 (0.0)	675 (-6.11)
Human labour (Million days)	210.14 (14.78)	46.88 (15.45)	1118.6 (13.94)	39.91 (13.96)	9230 (10.0)	4303 (21.14)	261 (-17.9)	360 (95.65)	60 (-4.76)	148 (-9.20)	1010 (32.70)	2486 (17.76)	332 (-13.5)	746 (-14.8)	639 (-14.2)	444 (184.6)	407 (0.0)	675 (-6.11)
Risk (Billion Rs.)	155.14 (-15.2)	34.42 (-15.21)	834.9 (-14.95)	29.03 (-17.1)	7073 (-15.7)	2869 (-19.2)	261 (-17.9)	170 (-7.60)	60 (-4.76)	148 (-9.20)	344 (-54.8)	1913 (-9.37)	332 (-13.5)	746 (-14.8)	639 (-14.2)	144 (-7.69)	407 (0.0)	675 (-6.11)

Note :Figure in parentheses represents percentage change over existing level.

TABLE 4.2.26 RESOURCE USE PATTERN IN PAY OF MATRIX FOR THE FOUR OBJECTIVES FOR UTTAR PRADESH, 2014-15

PARTICULARS	EXISTING USE	PLANS			
		1	2	3	4
Kharif fertilizer (000 tons)	1184.396	1339.210 (13.07)	1345.410 (13.59)	1345.410 (13.59)	98.463 (-15.69)
Rabi fertilizer (000 tons)	449.566	510.868 (13.63)	510.868 (13.63)	510.868 (13.63)	402.457 (-10.47)
Kharif Capital (billion Rs.)	58.360	66.329 (13.65)	66.511 (13.96)	66.511 (13.96)	47.124 (-19.25)
Rabi capital (billion Rs.)	24.004	27.290 (13.68)	27.290 (13.68)	27.290 (13.68)	20.961 (-12.67)
Total human labour (million man days)	981.7	1117.0 (15.54)	1118.6 (15.71)	1118.6 (15.71)	834.4 (-13.63)

Note : Figure in parentheses represents percentage change over existing level

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