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Multi Objective Crop Planning For Optimal Benefits

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ABSTRACT

Overall development of the Country depends on Agriculture which in turn depends on Water and Land resources. The supply of land & water for irrigation in right time and right quantity for various crops is the key for the optimum agricultural production. This requires proper planning and management process of water resources projects and appropriate technology for optimal utilization of available resources. Also Keeping in view of socio economic conditions, the present study makes an attempt to develop different Crop Planning strategies which increases the productivity with minimum input cost with the constraints of available resources like water usage and also labour, fertilizers, seeds, etc., and ultimately getting maximum net benefits. Multi objectives are framed by formulating three single objective functions for Multi crop model and for two seasons are formulated in LP for maximizing the net benefits, minimizing the cost and minimizing the water usage by keeping all other available resources (such as cultivable land, seeds, fertilizers, human power, pesticides, cash etc)as constraints. RDS Rajoli Banda Diversion scheme area, Mahaboobnagar, AP, India is taken as a case study and solved through optimization techniques linear programming and is solved with Lingo student solver version 12, Lingo software. The results reveal that optimization approach will significantly improve the annual net benefits with optimal crop areas allocation.

Key words: Optimization techniques, Linear Programming, optimal crop planning, deficit water supply, max net Benefits, Multi Objective Crop Planning.

1.0 INTRODUCTION:

Water resources management and planning under limited resources (such as water, land, production cost ,man power, fertilizers ,seeds, pesticides, etc.) is one of the classical problems of optimization techniques. Crop planning of the irrigation project is the land area, that is provided for cultivating each crop. Generally crop pattern is constructed based on the land area that is used to be cultivated in the previous season, depending on water resources. Several crop patterns are not considered in terms of economic basis. Therefore farmer needs to have the optimum cropping pattern which will maximize the economic returns.

There are three possible modeling approaches depending on the water availability in the schemes based on which decisions can be made regarding the allocation of land and water to different crops and the schedule of operation of the canal system. First one is when the water supply in the scheme is adequate. In this case the allocation process is comprised of optimally allocating the area to different crops such that maximum yield per unit area is obtained (area allocation model).The second is when the water supply is limited but the cropping pattern (areas) is pre decided. In this case the limited water needs to be distributed to different crops such that maximum production and benefits are obtained from the entire scheme (Water allocation models).The third case is when the water supply is limited and the cropping patterns (areas) can be chosen freely. Both water and area to be allocated optimally to different crops to obtain maximum production and benefits in the scheme (Land and Water allocation model).But the present study concentrates only on the Land allocation of various crops and the Water allocation is planned at a later stage as irrigation scheduling .Rajolibanda Diversion scheme is one of the small scale irrigation projects. The basic purpose of this project is to provide irrigation water around 60,000 acres in Mahaboob nagar and 25,000 acres in Kurnool district of A.P.

1.1. Review of Literature:

Normally LP is an optimize technique which is widely used to allocate the limited resources because of the proportionate characteristics of the allocation problem's. C. Maji and Earl O. Heady (1980) developed optimal reservoir management and crop planning under deterministic and stochastic inflows. A deterministic programming model was first formulated to indicate the optimal storage of reservoir water, the transfer of water to the producing regions and the spillage of water from the reservoir. A chance-constrained model was constructed to evaluate potential violations of the deterministic model. Both emphasize more dependence on rabbi and less on kharif crops. The chance-constrained especially suggests use of more water in the rabi season.

K. Srinivasa Raju, et.al. (1998) developed multi-objective fuzzy and stochastic linear programming and it developed for the evaluation of management strategies .The irrigation planning scenario considered 3 conflicting objectives like net benefits, crop production and labor employment. They demonstrates how vagueness and imprecision in the objective function values to quantified by membership functions in a fuzzy multi-objective frame work.

F.S.Royee et.al. (2000) studied a model based optimization of crop management for climate forecasting applications, the conventional use of crop models limit on experiment to a small predetermined subset of the possible combinations of variables. Laxmi Narayan Sethi,et.al.(2002) developed the optimal crop planning and conjunctive use of water resources due to increasing trend of intensive rice cultivation in a coastal river basin. For effective management, two models have been developed viz . . . . Ground water balance sheet model and optimum cropping and ground water management model. A ground water balance models has been developed by considering mass balance approach. The components of it are rainfall, irrigated rice and non-rice field base flow from rivers and seepage flow from surface drains. Optimization model using LP is developed for optimal cropping and ground water management. These models were applied to a portion of a costal river basin in Orissa state, India.

P.Ssrivastava et.al. (2002) described a methodology which integrated a genetic algorithm (GA) with a continuous simulation, watershed scale NPS pollution model, annualized agricultural non point source pollution model to optimize the best management practices on a field by field basis for a entire water shed. The optimization analysis was performed to identify BMP that minimized long term water equality degradation and maximized net form to a annual basis.

Takeshi Itoha et.al. (2003) formulated the crop planning problem as a liner programming problem. They assumed the profit co-efficient for agricultural products aren't certain values because of influence on future with uncertain (stochastic) values are considered for decision making in agricultural forms.

Baney M. malti et.al. (2006) applied green water Re-capitalization for optimizing agricultural productivity in eastern and southern Arabica for managing poor agricultural productivity water distribution problem.

F. Camacho et.al. (2006) studied management and optimization of water resources in irrigated agriculture through the use of remote sensing, agro meter orological data and information technologies.

M. Janga Reddy and D.Nagesh Kumar (2007) have evaluated the strategies for crop planning and operation of irrigation reservoir system using multi-objective differential evolution. In this study multi-objective differential evolution (MODE) approach is proposed for the simultaneous evolution of optimal cropping pattern and operation policies for a multi-crop irrigation reservoir system. Under varying hydrological conditions, the fixed cropping pattern with conventional operating rule curve policies, a nonlinear multi-objectives optimization model is formulated MODE model can be used to evolve different strategies for irrigation planning and reservoir operation policies and to select the best possible solution appropriate to the forecasted hydrologic condition.

Metaheuristics Millie panta, et.al. (2008), studied the estimation of optimal crop plan using nature inspired. Irrigation management has gained significance due to growing social needs and increasing food grains while the resources have limited and scare. It includes optimal allocation of water for irrigation purposes and optimal cropping pattern for a given land area with an objective to maximize economic returns, to estimate unknown minimum quantities of these resource inputs available are obtained with the help of crop planning model itself.

D.K. Sharma (2008) developed a multi objective programming techniques by name lexicographic goal programming (LGP) model. It is used for optimal allocation of land under cultivation and to propose an annual agricultural plan for optimal allocation of land under cultivation and to propose an annual agriculture plan for the various crops, which helps in obtaining different solutions in the decision making environment.

S.A.Mohanddes and Mohd. Ghazali Mohayidin (2008) ,applied fuzzy techniques for agricultural production planning in a watershed. These are large-scale regions where the agricultural production planning is associated with multiple objectives, including economic, social and environmental targets. It plays a vital role in all agricultural planning because some factors aren't fully controllable while some input data such as demand, resources, costs and objective functions are imprecise. The multi-objective mathematical programming model focuses on 3 objectives simultaneously, such as profit maximization, employment maximization and erosion minimization are subjected to 88 constraints.

N.Vivekanandan, et.al. (2008) studied optimization/plans of cropping pattern using goal programming approach. They considered Irrigation planning and scheduling are essential components of water management in irrigated agriculture. For maximization of net return, protein and calorie values with minimum land and water for Barna command area. The factors like amount of net return, utilization of surface and ground water by different plans are considered for the selection of best cropping of GP for optimization of cropping pattern for command area.

Present study concern with socio economic aspects of the former to get maximum net benefits

,and optimal usage of available resources by formulating multi Objective model in LP

1.2. MODEL FORMULATION:

There are two important seasons namely kharif starting from June ending with November & Rabi season starting from December ending with May. RDS is a diversion scheme project on the river Thungabadra and the main canal of this scheme further divided into 48 distributaries with different capacities of irrigation water supply. For the present study the data has been collected from the different ministries of Irrigation and Agriculture of Andhra Pradesh and also from the department of statistics and economics, revenue etc. and presented as revenue per unit yield of crop (Ri), Investment input cost per unit yield of crop (Ci), water requirement per unit land of ith crop (Wi), Yield of ith crop per unit land (Yi), Extent area of ith crop (Ai), Total irrigated land (At),Total cultivated land(A),Total availability of water(Wa), Minimum brake-even yield of the crops(Ym),Maximum possible yield of all crops (Ys) etc.The data from above source also gives us cost on seeds for ith crop per unit area of land(CSi), cost on fertilizers for ith crop per unit area of land(CFi), cost on pesticides for ith crop per unit area of land(CPi), cost on Human power for ith crop per unit area of land(CHi), cost on Animal & Other labour for ith crop per unit area of land(CAi),cost on Cash rent for ith crop per unit area of land(CRi), cost on land revenue for ith crop per unit area of land(CLRi), cost on Unforeseen expenditure for ith crop per unit area of land(CUi), cost on Gross inputs for ith crop per hectare of land(GCi) etc. Along with their total possible investment costs namely CS, CF, CH, CR, CA, CLR, CU and GC. The raw data requires formatting for identification of inputs and the raw statistical data as per the requirements to be incorporated as inputs. After formatting the statistical data we have run the optimal programming problem on Lingo Software 12. We have obtained the optimal section of decision variables on three accounts for obtaining (1) Maximum Net Profits, (2) Minimum Investment Costs, (3) Minimum use of water resources. The outputs were analyzed with suitable statistical graphs and are placed below.

1.3.Objective Functions :

1.3.1.Objective-I: Profit Maximization

Let A_i be the extent of area to be cultivated for i^{th} crop, where i=1, 2, 3, 4,5,6,7.

Let Y_i be the yield in tonnens of i^{th} crop, per unit area (per hectare); Let R_i be the value of the product per tone; Total revenue on i^{th} crop per tonne per hectare = $Y_i R_i$; The revenue of the i^{th} crop on total yield = $R_i Y_i A_i$; The total revenue on all the Seven crop is $T_R = \sum_{i=1}^{n} Ri\ Yi\ Ai$; for n=7

Let C_i be the input/investment cost per unit (per tonne) of i^{th} crop; Cost on Y_i units of yield per unit area is $C_i Y_i$; Cost for Y_i units of yield for A_i units of area = $C_i Y_i A_i$; The total investment cost for all crops for all the extent area is $T_C = \sum_{i=1}^{7} Ci\ Yi\ Ai$;

Total net value for productions of the crops = $T_C = \sum_{i=1}^{7} Ci\ Yi\ Ai$

Let Z_1 be the net profit (revenue) then $Z_1 = T_R - T_C$; $Z_1 = \sum_{i=1}^{7} Ri\ Yi\ Ai - \sum_{i=1}^{7} Ci\ Yi\ Ai$

Maximize Z_1= ; n=7…………

(1)

1.3.2.Objective-II: Inputs cost minimization

$$\text{Min } Z_2 = \sum_{i=1}^{n} Ai\,(CSi + CFi + CPi + CHi + CAi + CRi + CLRi + CUi)$$

…… (1.1)

CS_i be the cost on seeds per unit of land (per hectare) for i^{th} crop;

CF_i be the cost on fertilizers per unit of land (per hectare) for i^{th} crop;

CP_i be the cost on pesticides per unit of land (per hectare) for i^{th} crop;

CH_i be the cost on human power per unit of land (per hectare) for i^{th} crop;

CA_i be the cost on animal and other labour per unit of land (per hectare) for i^{th} crop;

CR_i be the cost on Cash rent per unit of land (per hectare) for i^{th} crop;

CLR_i be the cost on land revenue per unit of land (per hectare) for i^{th} crop;

CU_i be the cost on gross input per unit of land (per hectare) for i^{th} crop;

1.3.3.Objective - III: Water usage minimization

$$\text{Min } Z_3 = \sum_{i=1}^{n} (WKi + WRi)Ai; \quad \text{for } n=7$$ ………… (1.2)

Where WKi water available in kharif season

WRi water available in rabi season

1.4.Formulation of Constraints:

Constraint on water availability

$$\sum_{i=1}^{n} Wi\,Ai <= W_A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where WiAi – Total water requirement for all crops

WA - Average water availability

Constraint on land variability

$$\sum_{i=1}^{n} \lambda i\,Ai <= A_T \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

Where λ_i is the weight coefficient

λ_i Ai is total area for crop planting

Constraint on minimum yield requirement

$$\sum_{i=1}^{n} Yi\,Ai >= Y_{min} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.2)$$

Where Minimum yield requirement of i^{th} crop in A_i units of Area = Y_i. A_i

Ymin is minimum yield requirement for all crops

Constraint on maximum yield requirement

$$\sum_{i=1}^{n} YiAi <= Y_{max} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

Where Ymax is maximum yield requirement for all crops

Constraint on total availability of land for cultivation

$$\sum_{i=1}^{n} Ai <= A \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.4)$$

Where A is total availability of land for cultivation

Constraint on investment cost on seeds

$$\sum_{i=1}^{n} CSi\,Ai <= CS; \text{ for } n=7 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.5)$$

Constraint on investment cost on fertilizers

$$\sum_{i=1}^{n} CFi\,Ai <= CF; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.6)$$

Constraint on investment cost on pesticides

$$\sum_{i=1}^{n} CPi\,Ai <= CP; \ldots\ldots\ldots\ldots\ldots\ldots (2.7)$$

Constraint on investment cost on human power

$$\sum_{i=1}^{n} CHi\,Ai <= CH; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.8)$$

Constraint on investment cost on animal & other labour

$$\sum_{i=1}^{n} CAi\,Ai <= CA; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.9)$$

Constraint on investment cost on cash rent

$$\sum_{i=1}^{n} CRi\,Ai <= CR; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.10)$$

Constraint on investment cost on land revenue

$$\sum_{i=1}^{n} CLRi\,Ai <= CLR; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.11)$$

Constraint on investment cost on unforeseen expenditure

$$\sum_{i=1}^{n} CUi\,Ai <= CU; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.12)$$

Constraint on investment cost on gross input

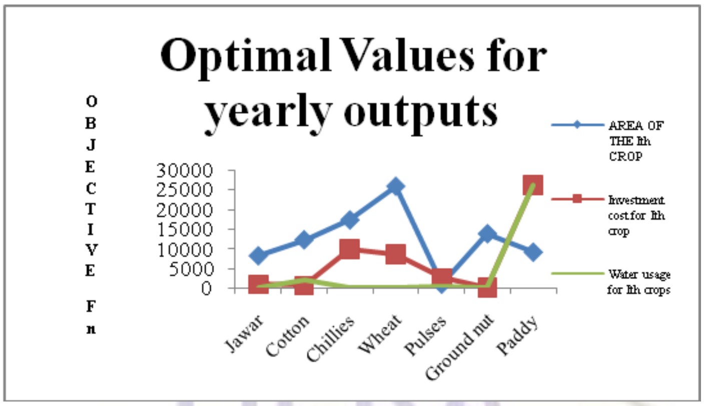
$$\sum_{i=1}^{n} GCi\,Ai <= GC; \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.13)$$

And Ai >= 0 ; for n=7 ……………………… (2.14)

OUTPUTS OF OBJECTIVE VALUES (Table:1)

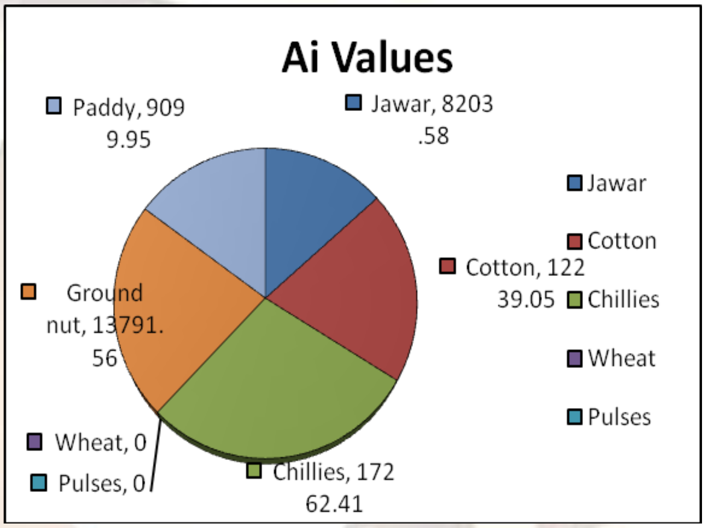
Z1: Net Profit Maximization RS (in thousands)	Z2: Investment Cost Minimization Rs(in thousands)	Z3: Water Usage Minimization (MCM)
725779	41153	8023.568

OPTIMAL LAND ALOCATION FOR VARIOUS CROPS



OPTIMAL LAND ALLOCATIONS (OVERALL YEAR) (Table:2)

Crop Name Area of the Ith crop in Acers	**Max net benefits(thousands) Z1** Optimal crop area	**Investment cost for Ith cropRs(thousands) Z2** Optimal crop area	**Water usage for Ith crops (MCM) Z3** Optimal crop area
Jawar	**8203.57**	**884.76**	**155.18***
Cotton	**12239.10**	**646.95***	**1992.85**
Chillies	**17262.40**	**9855.03***	**140.58***
Maize	**25791.00***	**8522.76***	**71.02***
Pulses	**1031.80***	**2527.30***	**317.46***
Ground nut	**13791.60**	**63.00***	**204.54***
Paddy	**9099.95**	**26274.82**	**26078.60**
MEAN	**12488.48**	**6967.8**	**4137.17**
SD	**6627.43**	**9880.78**	**9759.55**
C.V	**130.62**	**39.26**	**46.07**



OPTIMAL LAND ALLOCATIONS

(KHARIF SEASON) (Table:3)

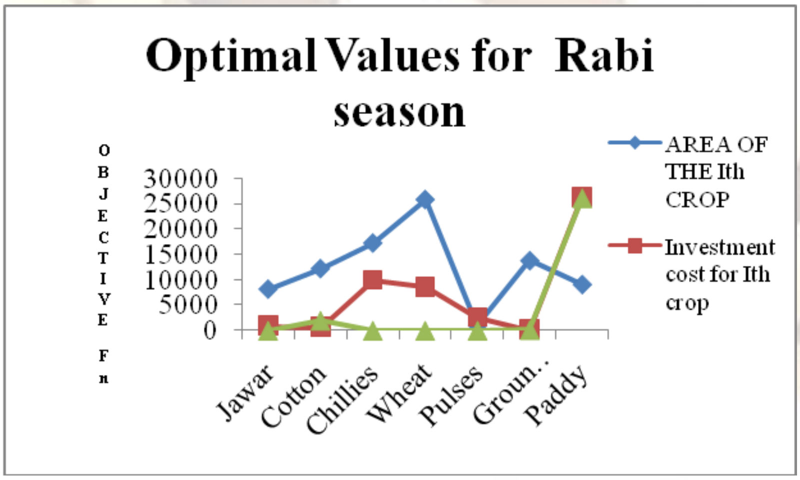
OPTIMAL LAND ALLOCATIONS

(RABI SEASON) (Table:4)

Crop CS CF CP CH CA CR CLR CU Revenue Investment Yield

Crop Name Area of the Ith crop in Acers	Max net benefits Optimal crop area	Investment cost for Ithcrop Optimal crop area	Water usage for Ithcrop Optimal crop area
Jawar	8203.57	884.76	40.39*
Cotton	12239.05	646.95*	22855.70
Chillies	17262.41	9855.03*	32.14*
Maize	25791.01*	8522.76*	21.96*
Pulses	1031.80*	2527.30*	27.65*
Ground nut	13791.56	63.00*	155.00*
Paddy	9099.95	26274.82	86.02*
MEAN	12488.48	6967.8	3316.98
S.D	6627.43	9880.72	8638.65
C.V	130.62	39.27	37.80

Crop Name In Acers	Max net benefit Optimal Areas	Investment cost Optimal Areas	Water usage Optimal Areas
Jawar	8203.57	884.76	40.72*
Cotton	12239.10	646.95*	1992.85
Chillies	17262.40	9855.03*	43.28*
Maize	25791.00*	8522.76*	20.76*
Pulses	1031.80*	2527.30*	42.35*
Ground nut	13791.60	63.00*	157.23*
Paddy	9099.95	26274.82	26078.60
MEAN	12488.48	6967.8	4053.68
S.D	6627.43	9880.72	9759.55
C.V	130.62	39.27	41.06



INPUT VALUES FOR OPTIMAL CROP PLANNING OBJECTIVE FUNCTION (Table:5)

Linear Program Results (Table:6)

	Maximum Benefits	Minimum Input Cost	Minimum Water Usage
Annual Optimal Crop Areas	$Z1=0.375*10^8$ Optimal crop areas	$Z2=0.7264*10^8$ Optimal crop areas	Z3=14.89 Optimal crop areas
Jawar	1981.23	2703.87	18768.22
Cotton	7867.36	245.112	0
Chillies	9138.55	19008.02	18293.08
Maize	53172.2	16075.15	0
Pulses	571.29	5123.198	0
Ground nut	44965.12	2271.28	0
Paddy	2091	25703.55	0

1.5. LINGO PROGRAM CODE:

```
data:
R1=2000; R2=6079; R3=18000; R4=3300; R5=5000; R6=2225; R7=2200;
c1=1125.6; c2=4843.733; c3=4133.6; c4=809.66667; c5=2017.5; c6=816.8637;
c7=1060.375;
W1=0.000469;W2=0.001089;W3=0.000333;W4=0.000533;W5=0.000507;W6=0.001324;
W7=0.002719;
l1=1.598;l2=0.564;l3=0.785;l4=0.092;l5=0.657;l6=0.569;l7=2.156;
y1=2.13;y2=3.75;y3=2.50;y4=3.00;y5=0.80;y6=1.25;y7=3.0;
cs1=52.5;cs2=75;cs3=375;cs4=25;cs5=445;cs6=90;cs7=525;
cf1=421;cf2=850;cf3=1200;cf4=1000;cf5=600;cf6=170;cf7=155;
cp1=25;cp2=307.5;cp3=3955;cp4=3995;cp5=65;cp6=100;cp7=77.5;
ch1=516.5;ch2=1306.5;ch3=3830;ch4=3830;ch5=733;ch6=201;ch7=303;
ca1=325;ca2=432.5;ca3=870;ca4=877;ca5=450;ca6=175;ca7=300;
clr1=27;clr2=55.5;clr3=50;clr4=50;clr5=50;clr6=50;clr7=25;
cr1=53.5;cr2=101;cr3=384;cr4=372;cr5=86;cr6=28;cr7=56;
cu1=57;cu2=142;cu3=533;cu4=516;cu5=121;cu6=42;cu7=75;
gc1=1510.5;gc2=2842.5;gc3=10664;gc4=10334;gc5=2429;gc6=814;gc7=1386.5;
Wa=2099.028;
at=61030;
ym=85709;
yx=241272.75;
A=87500;
s=13840732.14;
cf=38326840
cp=74325821.43;
ch=93463085.71;
cla=29900340.71;
clr=2680960.714;
cr=9420416.429;
gc=261387131;
END DATA max=(R1-C1)*Y1*A1+(R2-C2)*Y2*A2+(R3-C3)*Y3*A3+(R4-C4)*Y4*A4+(R5-
C5)*Y5*A5+(R6-C6)*Y6*A6+(R7-C7)*Y7*A7;
W1*A1+W2*A2+W3*A3+W4*A4+W5*A5+W6*A6+W7*A7<=Wa;
l1*A1+l2*A2+l3*A3+l4*A4+l5*A5+l6*A6+l7*A7<=at;
y1*A1+y2*A2+y3*A3+y4*A4+y5*A5+y6*A6+y7*A7>=ym;
y1*A1+y2*A2+y3*A3+y4*A4+y5*A5+y6*A6+y7*A7<=yx;
cs1*A1+cs2*A2+cs3*A3+cs4*A4+cs5*A5+cs6*A6+cs7*A7<=cs;
cf1*A1+cf2*A2+cf3*A3+cf4*A4+cf5*A5+cf6*A6+cf7*A7<=cf;
cp1*A1+cp2*A2+cp3*A3+cp4*A4+cp5*A5+cp6*A6+cp7*A7<=cp;
ch1*A1+ch2*A2+ch3*A3+ch4*A4+ch5*A5+ch6*A6+ch7*A7<=ch;
ca1*A1+ca2*A2+ca3*A3+ca4*A4+ca5*A5+ca6*A6+a7*A7<=ca;
clr1*A1+clr2*A2+clr3*A3+clr4*A4+clr5*A5+clr6*A6+clr7*A7<=clr;
cr1*A1+cr2*A2+cr3*A3+cr4*A4+cr5*A5+cr6*A6+cr7*A7<=cr;
cu1*A1+cu2*A2+cu3*A3+cu4*A4+cu5*A5+cu6*A6+cu7*A7<=cu;
gc1*A1+gc2*A2+gc3*A3+gc4*A4+gc5*A5+gc6*A6+gc7*A7<=gc;
```

A1+A2+A3+A4+A5+A6+A7<=A;
A1>=0;A2>=0;A3>=0;A4>=0;A5>=0;A6>=0;A7>=0;
End
END

1.6.ANALYSIS

Statistical data outputs produced through a LINGO program. From the results it is observed that in kharif season farming of Maize has maximum extended area of 25791 and pulses are in minimum extended area of 1031.8, regarding the Objective:1. The average allocation of land for each crop is 12488 acres with standard deviation of 7774 acres and C.V equal to 161. Regarding the decision variables on investment cost for crop the maximum is for paddy with 26275 acres and minimum is Groundnut with 63 acres. As per water usage of the crop is concerned it is suggestible to cultivate maximum land for cotton with 22856 acres and the minimum is suggested for the crop of Maize with 22 acres. The average allocation of land for each crop, in the view of investment cost is equal to 6967.8 acres where as in the view of water usage of crop, the average allocation of land per each crop is 3317 acres. Observing the phenomena kharif season, objective 3(water usage for ith crop) has the maximum consistency regarding allocation of land for each crop.

Observing the outputs of Rabi season, the minimum allocated land for objective 1 is to the crop plusses with 1032 acres and the maximum allocation of land to the crop Chilies is 17262 acres. Regarding the objective 3, the minimum allocation of the land is 21 acres to the crop Maize where as the maximum allocation of land is 26079 acres for paddy. The mean allocation of land for each crop is 4053 acres keeping objective 3 in mind. Regarding the decision variables on investment cost for crop the maximum is for paddy with 26275 acres and minimum is Groundnut with 63 acres. The average allocation of land for each crop, in the view of investment cost is equal to 6967.8 acres. Comparing the objectives 1, 2, 3, the objective 3 is more consistent with minimum C.V is equal to 41.

Regarding overall comparison irrespective of seasons, the average allocated land for crop is equal to 12488 acres in objective 1, 6968 acres for objective 2 and 4137 acres for objective 3. Among the objective 1 the minimum allocation of land is for pulses with 1032 acres. Whereas the maximum allocation of land is for the crop Maize with 25791 acres. Regarding objective 2, the minimum allocation of land is for Groundnut with 63 acres; whereas the maximum allocation is for the crop paddy with 26275 acres. The average allocation for crop in objective 2 is 6968 acres. Regarding objective 3 the minimum allocation of land to the crop Maize with 71 acres and the maximum allocation of land is for paddy crop with 26079 acres. The average allocation for each crop in objective three 4137 acres. Comparing all the three objectives, objective 3 considered to be more consistent as C.V is minimum with 46.07.

The details of land allocation outputs were presented in tables as well as graph for better understating decision making. These plans can be implemented for the RDS area. So that the farmers may get the optimal profits and cost minimizations.

1.7.SUMMARY AND CONCLUSION

The present study considered the crop planning as of the people concern to farming sector. Farmer has to set his goals of achieving the objectives like maximizing returns and plan his course of action on multi objective tasks. And hence the programming problem has to be formulated to suit the farmer needs.

Rajolibanda Diversion Scheme is a project comes under small scale irrigation program, was constructed across the river Thungabadra at Rajoli village, Mahaboobnagar, A.P, India. The total extent of irrigated facility area is around 87,000 acres. The water is released in two seasons depends on the water inflow to the project. The Government used to distribute the water from this dam into these seasons for agriculture purpose namely Kharif and Rabi. There are seven prime crops under RDS namely Jawar, Cotton, Chillies, maize, Pulses, Groundnut, Paddy.

This irrigation scheme has to plan the allocation of their agricultural land to the mentioned 7 crops with constraints of water supply during the seasons Kharif and Rabi. We have studied the optimal programming problem on 3 separate cases namely (1) Optimal land allocation for different crops in Kharif season, (2) Optimal land allocation for different crops in Rabi season and (3) Optimal land allocation for different crops in both the seasons(overall).

Enough size of literature was collected on optimal crop planning and the literature suggests the decision variable as Ai (Area of cultivation for ith crop). As statistical data provides information on various heads, and the information furniture literature in optimal crop planning motivated to develop an optimal crop planning through linear programming problem for multi objective and multi constraints. The present modal is made on an assumption that the net revenue generated per unit area of crop over the entire command area varies with the crop cost incurred and the net revenue generated and the crop water demand is not uniform,hence the proram is nonlinear resulting in the corresponding areas as shown in the tables above. Alternatively assuming the net revenue per unit Area* Area, the variation of this is negligible , and the depth of application of water is uniform , the program became linear and the corresponding objective function Z1, Z2, Z3 the optimal crop areas are obtained as shown in table No: 6 . It exactly plays as a vital tool in Portfolio management of a farmer in irrigation and agricultural sector...

Regarding overall comparison irrespective of seasons, the average allocated land for crop is equal to 12488 acres in objective 1, 6968 acres for objective 2 and 4137 acres for objective 3. Among the objective 1 the minimum allocation of land is for pulses with 1032 acres. Where as the maximum allocation of land is for the crop chilies with 17262 acres. Regarding objective 2, the minimum allocation of land is for Groundnut with 63 acres; where as the Using soft computing techniques such as genetic algorithm, a heuristic technique , more efficient cropping patterns are obtained for maximizing benefits for any irrigation project in India.

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maximum allocation is for the crop paddy with 26275 acres. The average allocation for crop in objective 2 is 6968 acres. Regarding object 3 the minimum allocation of land to the crop Maize with 71 acres and the maximum allocation of land is for paddy crop with 26079 acres. The average allocation for each crop in objective three 4137 acres. Comparing all the three objectives, objective 3 considered to be more consistent as if C.V is minimum with 46.07.

The details of land allocation outputs were presented in tables as well as graph for better understating & decision making. These plans can be implemented for the RDS area. So that the farmers may get the optimal profits and cost minimizations.