International Journal of Applied Mathematics
& Statistical Sciences (IJAMSS)
ISSN(P): 2319-3972; ISSN(E): 2319-3980
Vol. 5, Issue 3, Apr - May 2016; 1-6

International Academy of Science,
Engineering and Technology
Connecting Researchers; Nurturing Innovations

MATHEMATICAL MODELLING FOR OPTIMAL CROP PLAN TO NET BENEFIT MAXIMIZATION

K. J. SHINDE

Department of Mathematics, College of Agricultural Engineering & Technology,

Dr. Panjabrao Deshmukh Agricultural University, Akola (M.S), India

ABSTRACT

The linear programming mathematical model was developed for resources management plan with the objective function for allocation of land and water for different crop activities to maximize the net return taking in to constrain land capability classification, availability of water in different season, crop water requirements, food requirement and affinity towards the crops of the peoples in selected district.

The analysis of the linear programming mathematical model was done using MATLAB software and conclude that, in existing crop plan during kharif season major area is under cotton (43.45%) followed by jowar (17%) whereas in proposed optimal crop plan without capital constraints major area was allocated under soybean (30%), cotton + tur (20%) of the total cultivable area of the selected district. In rabi major area in existing is under gram (5.2%) whereas in proposed plan area is allocated to wheat (20%), gram (20%). In existing summer area is 0.18% and annual was nil whereas in proposed plan is 3% and 4.13% respectively. In existing gross investment and net return per hectare was 10341 and 5203 Rs/ha, whereas in proposed plan is 14864 and 8833 Rs/ha. In proposed plan net return per hectare increases by Rs.3630.

KEYWORDS: Constraint, Crop Plan, Linear Programming Model

INTRODUCTION

Food is the basic need of mankind, which is fully dependent on agriculture. Land and water are two major natural resources essential for crop production and are scarce, so it is necessary to use them in best possible way to get maximum production. Judicious management of land, water, labor and other inputs in the area has a good potential and may yield better result. To irrigate more area and to achieve maximum benefits from the area, it is necessary to use land and water efficiently and optimally. Therefore, it is essential to develop optimal strategies through application of mathematical program to suggest the best possible combination of all constraints to maximize the net profit by considering the stochastic nature of hydrological events.

Optimization techniques are applicable in cases where limited resources are to be allocated in an optimum manner with a view to maximize the net returns. This study is undertaken to maximize net benefit by allocating the optimal area to various crops considering the resources constraints such as land, water, food requirement etc.

MATHEMATICAL MODEL

To optimize net benefit linear programming model was developed.

Linear Programming Model

The following assumptions were made while developing the model.

- The relationship between the variables in the objective function and the constraints are linear.
- All parts of the land under consideration are put to the same management practices.
- All inputs other than water, viz. seeds, fertilizers, weedicides, labours and pesticides of desired quality are available in adequate quantities.
- Time and period of crop sown is same in every year.
- Crop yield considered is same throughout the district.
- Ground water is used only during winter and summer season.
- Gross irrigation efficiency is taken as 75 percent for surface water.
- Rainfall is uniform in the district.

The objective function can be written as follows

$$Max\ NB = \sum_{i=1}^{n} NB_i X_i \quad (1)$$

Where,

NB_i = Net benefit from ith crop, Rs/ ha

X_i = Area under ith crop, ha

$$Max\ NB = 5910\ C_k + 4220\ J_k + 6225 C_{T_k} + 5630\ S_{T_k} + 4860 M_k + 5610 G_k + 5120 S_k$$

$$+ 4405 S_{U_k} + 5060\ VG_K + 6460 VO_K + 7070\ W_R + 4580 G_R + 4230\ SA_R$$

$$+7500 VG_R + 7980 VO_R + 8460 VG_S + 8220\ VO_S + 12500 F_A + 3750 A_A + 7500 D_A$$

where first notations are of different crops as C-cotton, J-jowar, C_T –cotton+tur, M-mung, G-groundnut/gram, wheat-W,VO-other vegetables, VG-green vegetables, A-silvipasture, F-fruits, D-dry land horticulture and second notations are K-kharif, R-rabi, S-summer and A-annual.

Optimal crop plan formulated under following constraints:

Area Constraint

The area under each crop during the growing season should not exceed total area available for cultivation in the district.

$$\sum X_i \leq A \quad (2)$$

Where A is total area available for cultivation, ha

For kharif season -

$CK + JK + C_TK + S_TK + MK + Gk + SK + SuK + VGK + VOK + FA + F + AA + DA \leq 477778$

For rabi season -

$CK + C_TK + S_TK + WR + GR + SAR + VGR + VOR + FA + AA + DA \leq 477778$

For summer season -

$VGS + VOS + FA + AA + DA \leq 477778$

Water Constraint

The water requirement of all crops in the district should be fulfilled by the existing water resources in the district.

$$\sum W_i X_i \leq W \quad (3)$$

Where,

W_i: Depth of water required for i^{th} crop in particular season, cm

W: Total water availability in the district, ha-cm

Availability of water for kharif season -

$44\ CK + 45.36\ JK + 42\ C_TK + 35\ S_TK + 27\ MK + 38.91\ GK + 41.23\ SK + 35.53\ SuK + 33.74\ VGK + 30.98\ VOK + 45\ EA + 37.2\ AA + 47.9\ DA \leq 24352872.34$

While calculating the water available in kharif season effective rainfall available to plants is estimated by deducting interception, percolation, recharge and runoff as 65.6 % of average kharif rainfall i.e 683.67mm.Thus (683.67x0.656)543000) = 24352872.34

Availability of water for rabi and summer season -

$11.68CK + 11.51\ C_TK + 11.29\ S_TK + 42.37\ WR + 25\ GR + 28.10\ SAR + 49.1\ VGR + 14.97\ VOR + 60.1\ VGS + 52.96\ VOS + 105\ FA \leq 12201001.97$

While calculating the water available in rabi and summer season available soil moisture, 70% of total runoff and ground water and effective rainfall are considered.

Food Requirement Constraint

Food available from the crops grown in the district should fulfill the actual food requirement of the people in the district.

$$\sum N_i X_i \leq N \quad (4)$$

Where,

Ni: Production of i^{th} crop, qtl/ha

N: Quantity of crop to be produced to fulfill food requirement of population, qtl

Thus,

Wheat $25WR \geq 20.3818X10^5$, Jowar $27.5JK \geq 8.78722X10^5$, Tur $3CTK + 3STK \geq 2.82228X10^5$, Gram $10\ GR \geq 0.87409X10^5$, Mung/ Udid $7.5\ MK \geq 0.8709X10^5$, Groundnut $10GK \geq 1.51840X10^5$, Soybean $15SK \geq 0.55142X10^5$,

Safflower 7 SR ≥ $0.55142X10^5$, Sunflower 10SUK ≥ $0.13788\ X10^5$, Fruits 150FA ≥ $1.98221X10^5$, Green leafy vegetables 65VGK ≥ $2.21096X10^5$, 70VGR ≥ $2.21096X10^5$, 65VGS ≥ $2.21096X10^5$ and Other vegetables 100VOK ≥ $1.59133X10^5$, 105VOR ≥ $1.59133X10^5$ 0VOS ≥ $1.59133X10^5$ in kharif, rabi and summer respectively.

Other Constraint*:* Considering land capability, affinity of farmers towards crops, risk of failure, market rate fluctuation lower and upper limits are given.

Non-Negativity Constraint: Area under different crops in various seasons and annual are non negative.

RESULTS AND DISCUSSIONS

The linear programming model for net benefit maximization was solved using MATLAB software under above various Constraints and optimum area allocation plan was obtained.

Existing Crop Plan

Major crops grown in area are cotton, jowar, cotton+tur, and mung in kharif season. In rabi wheat, gram, safflower, sunflower, jowar and in summer groundnut and sunflower. The existing crop plan is given in **Table 1**

Table 1: Existing Crop Plan of Selected District

Sr. No.	Name of Crops	Kharif, ha	Rabi, ha	Summer, ha
1.	Cotton	207600 (43.45)	-	-
2.	Jowar	82200 (17.20)	-	-
3.	Cotton + Tur	26100 (5.46)	-	-
4.	Soyabean + Tur	26100 (5.46)	-	-
5.	Mung/ Udid	65500 (13.71)	-	-
6.	Soybean	50300 (10.52)	-	-
7.	Sesame	1500 (0.32)	-	-
8.	Sunflower	2900 (0.61)	-	-
9.	Other kh. Cereals (bajra, maize)	2200 (0.46)	-	-
10.	Other kh. Pulses	400 (0.08)		
11.	Wheat	-	3400 (0.71)	-
12.	Gram	-	24000 (5.2)	-
13.	Safflower	-	1900 (0.39)	-
14.	Sunflower	-	1500 (0.32)	-
15.	Jowar	-	100 (0.02)	
16	Groundnut	-	-	500 (0.10)
17.	Sunflower	-	-	400 (0.08)
Cultivated area, ha		464800 (97.28)	30900 (6.27)	900 (0.18)
Total cultivable area, ha		477778		

Note: Figures in parentheses are percentage

Proposed crop plan without capital constraint is presented in **Table 2.** In existing plan major area is under cotton (43.45%) followed by Jowar (17.2%), mung/udid (13.7) and Soybean (10.52%) of cultivable area. Considering the net benefit maximization in the district wit out capital constraint the land allocation to different crops in kharif season viz. soybean crop (30%), followed by cotton + tur (20%), Cotton (12.87%) and groundnut (10%) In existing plan in Rabi season major area is under gram (5.2%). Where as in proposed plan major area is under wheat (20%) gram (20%) followed by safflower (10%) In summer and annual crops in existing plan area is 0.18% while in proposed plan area is allocated to summer green vegetable (2%) and fruits crops (1.13%) respectively.

Table 2: Proposed Crop Plan

Sr. No.	Name of Crops	Kharif, ha	Rabi, ha	Summer, ha
1.	Cotton	61493 (12.87)	-	-
2.	Jowar	23889 (5.00)	-	-
3.	Cotton + Tur	95556 (20.00)	-	-
4.	Soybean + Tur	47778 (10.00)	-	-
5.	Mung/ Udid	23889 (5.00)	-	-
6.	Ground nut	47778 (10.00)	-	-
7.	Soybean	143333 (30.00)	-	-
8.	Sunflower	4778 (1.00)	-	-
9.	Green vegetables	4779 (1.00)	-	-
10.	0^{th} Vegetable	4778 (1.00)		
11.	Wheat	-	95556 (20.00)	-
12.	Gram	-	95556 (20.00)	-
13.	Safflower	-	47778 (10.00)	-
14.	Rb. Green Vegetables	-	9556 (2.00)	-
15.	Rb. 0^{th} Vegetables	-	4778 (1.00)	-
16	Su. Green Vegetables	-		9556 (2.00)
17.	Su. 0^{th} Vegetables	-		4778 (1.00)
18.	Fruits	-	-	5393 (1.13)
19.	Silvipastur	-	-	4778 (1.00)
20.	Dry land Horticulture	-	-	9556 (2.00)
Cultivated area, ha		458051 (95.70)	253222 (53)	34877 (7.13)
Total cultivable area, ha		477778		

Note: Figures in parentheses are percentage

The investment and net benefit in existing 10341 and 5203 Rs/ha whereas in proposed 16057 and 8833 Rs/ha. In proposed plan net benefit increase by 3630 Rs/ha over existing

The area in kharif, rabi and summer in existing and proposed is shown in **Table 3.**

Table 3: Existing and Proposed Crop Plan, Gross Investment and Net Return in Selected District

Particulars	Area Under Existing Crop Plan	Area Under Proposed Crop Plan
Kharif, ha	464800 (97.28)	458051 (95.70)
Rabi, ha	30900 (6.47)	253222 (53.00)
Summer, ha	900 (0.19)	14333 (3.00)
Annual, ha	-	20544 (4.13)
Total, ha	496600 (103.94)	746150 (156.17)
Cultivable area, ha	477778	477778
Cropping intensity, %	103.94	156.17
Gross investment, Rs/ha	10341	16057
Net return, Rs/ha	5203	8833
Total net return of Selected district, Rs	248.6×10^7	422×10^7
Net return increases over existing, Rs/ha	-	3630

Note: Figures in parentheses are percentage

In existing cropping intensity was 103.94% where as in proposed it can be increased to 156.17%

CONCLUSIONS

- Gross investment and net return in proposed plan is 16057 and 8833 as against existing plan 10341 and 5203 Rs/ha.
- Net return increases over existing by Rs 3630 per ha.
- Cropping intensity increases from existing 103.94% to 156.17% in proposed plan.

REFERENCES

1. Ishtiaq hassan, Bhashir Ahmad, Manzoom Akhtar and Aslam, Use of linear cropping model to determine the optimum cropping pattern: A case study of Punjab, Electron. J. Environ. Agric. Food Chem http://www.sciencedirect.com, pp: 841-855
2. Kirti M, S.B. Jajoo, K. J. Shinde (2008) Optimal crop planning for Belura Watershed using linear Programming model A case Study, Green Farming, 1(9), 2008, 22-25.
3. Singh A. K., J. Singh, R. C. Purohit and Rashmi Singh, Optimal crop planning for Badliya command area in Rajasthan for maximizing crop benefits- A case study, Indian J. Soil Conservation, 33(2), 2005, 166-169.