



Research Paper

Determine optimal crop planning under conditions of water risk in Namakkal district of Tamil Nadu

■ **B. KAVITHA, M. UMA GOWRI AND R. SANGEETHA**

See end of the paper for authors' affiliations

Correspondence to :

B. KAVITHA
PGP College of
Agricultural Sciences,
NAMAKKAL (T.N.) INDIA
Email: kavisribala@gmail.com

Paper History :

Received : 02.02.2015;
Revised : 02.06.2015;
Accepted : 06.07.2015

ABSTRACT : Water is a critical input for success of agriculture and its ever widening technology creation. Water scarcity as a risk has always been a part of agriculture and farm business. Hence, management of available irrigation water assumes great importance in the field of agriculture. The present study was attempted in Namakkal district of Tamil Nadu, India, because of the availability of exclusive dry farms. In Namakkal district, blocks namely Namakkal, Mohanur, Pudhuchatram, Tiruchengode for each risky crop were purposively selected on the basis of area, production and productivity of those crops. Linear programming model was applied to derive optimal crop plan for the sample farms under water stress conditions. Optimization of crop portfolio for the selected farm is a type of risk management strategy. The decline in gross cropped area in Namakkal block would imply relatively less pressure on land that would again indicate the sign of bringing in sustainability of the productive capacity of the land. Even though the decline trend in net income, it showed that the resources which were used in the cultivation as efficiency factor in Pudhuchatram. The results indicated that water and other resources were used efficiently to get optimum pattern in the cultivation of different crops.

KEY WORDS : Water stress, Resource use, Farm size, Linear programming, Optimization

HOW TO CITE THIS PAPER : Kavitha, B., Uma Gowri, M. and Sangeetha, R. (2015). Determine optimal crop planning under conditions of water risk in Namakkal district of Tamil Nadu. *Internat. Res. J. Agric. Eco. & Stat.*, 6 (2) : 242-248.

INTRODUCTION :

Agriculture in India is one of the most primary sectors in the economy. It is the single largest sector occupation in the country and is also considered to be the riskiest business. Risk is inherent in agriculture since it mostly depends on the vagaries of nature (Bhowmick and Hazarika, 2007). Agricultural risks are exacerbated by a variety of factors, ranging from climate variability and change, frequent natural disasters, uncertainties in yields and prices, weak rural infrastructure, imperfect

markets and lack of financial services including limited span and design of risk mitigation instruments such as credit and insurance. These factors not only endanger the farmer's livelihood and incomes but also undermine the viability of the agriculture sector and its potential to become a part of the solution to endemic poverty of the farmers. The vulnerable groups like landless labourers and sharecroppers face a variety of risks which have a bearing on their steady flow of income and their ability to build income generating assets (IFMR-CIRM, 2008).

In the absence of availability or access to formal

risk management mechanisms in a rural environment, the asset poor households seek to manage risks through various informal strategies. They may choose to diversify their crops, store grain, engage in informal savings and credit, favour traditional techniques over modern technology and enter into share-cropping arrangements (Report: XI five Year Plan, 2007-2012). To a larger extent economizing farm will make use of advanced mathematical models and techniques in the formulations of suitable plans which can serve as the basis for management decisions. This study is one such attempt to help farmers with specific suggestion to reduce risk, with emphasis on understanding the influence of farm production risk. This study aims at improving the efficiency of production management of farmers by evolving an optimal production plan.

The present study stabs to determine the optimal crop planning under water stress conditions in Namakkal district of Tamil Nadu which was purposively selected for the study because it comes under the category of dry land tract. Agriculture is considered to be risky as it was carried out under stochastic nature of rainfall in the study in Gwem by valley of Zambia (Maleka, 1993). Hence, the selection of study area should be represent such agroclimatic conditions and risk situations. Further the availability of exclusive dry farms was considered as an important criterion while selecting the study area. And also they were selected for the present study taking into consideration of the following criteria. (1) The occurrence of frequent droughts made the block a highly risk prone area agriculturally. (2) Secondly the availability of irrigation facilities was considered. These criteria facilitated the selection of exclusively dry farms in the study area. Water was considered as the risky variable in the study area. For this present study, four blocks were selected purposively (Table A). In each block, one crop was selected based on the CV analysis of area and production.

In Namakkal district, blocks namely Namakkal, Mohanur, Pudhuchatram, Tiruchengode for each risky crop were purposively selected on the basis of area, production and productivity of those crops as presented in the Table

A. In each block, three villages were selected randomly and one crop was selected based on CV analysis.

MATERIALS AND METHODS :

Linear programming technique is defined as a mathematical technique, having many possible uses. In farm management it could be used for determining; (1) The best combination of (a) crops alone, (b) livestock alone, or (c) crops and livestock enterprises together; (2) The optimum of all these different enterprises and practices considered together (Heady, 1954).

Optimization of crop portfolio for the selected farm is a type of risk management strategy. For the present study, the farm similar to average farm size was selected as a representative farm. For each crop, one farm similar to average farm size was selected as representative farm and optimized. In linear programming models, the objective of the typical farm *i.e.*, maximization of net profit or cost minimization is achieved through optimal plan generated from its solution. Hence, it is the method of determining the best or optimal plan to the given farm under the given linear constraints. The objective function specified, *i.e.*, profit maximization or cost minimization, is linear in form and constraints on resource restrictions are specified in linear form. As normative tools, it always aims at combining the efficient enterprise giving weight age to constraints and profit maximization.

Components of LP problem :

There are three quantitative components in LP model. They are (1) an objective function; (2) resource requirements; (3) resource availability.

Algebraically it is stated in compact form as:

$$\text{Maximize } f = C'X$$

Subject to

$$AX \leq B \text{ or } AX \leq B$$

$$X \geq 0$$

where,

A is m Xn-matrix of technical co-efficients

Table A : Block wise crop details

Sr. No.	Name of the block	Crop	Area (ha.)	Production (Tonnes)	Productivity (kg per ha)
1.	Namakkal	Maize	665.69 (29.73)	679 (29.78)	1020 (80.76)
2.	Mohanur	Banana	958.40 (58.34)	40712.83 (41.35)	41965 (98.78)
3.	Pudhuchatram	Tomato	109.49 (38.42)	1225.59 (43.17)	9960 (92.24)
4.	Tiruchengode	Groundnut	72.11 (36.81)	114 (32.06)	1581 (87.53)

Source: District Agricultural Office, Namakkal

C is $n \times 1$ - vector of prices or other weights for the objective function.

X is $n \times 1$ - vector of activities (crops and livestock to be produced which are unknown decision variables).

B is $m \times n$ -vector of resources or other constraints, availability in physical units, such as labour, land, etc., and the objective function :

$$C \cdot X = f,$$

In expanded form it is written as:

$$\text{Maximize } f = C_1 X_1 + C_2 X_2 + \dots + C_n X_n$$

Subject to

$$a_{11} X_1 + a_{12} X_2 + \dots + a_{1n} X_n \leq b_1$$

$$a_{m1} X_1 + a_{m2} X_2 + \dots + a_{mn} X_n \leq b_m$$

$$a_{k1} X_1 + a_{k2} X_2 + \dots + a_{kn} X_n \leq b_k$$

$$a_{w1} X_1 + a_{w2} X_2 + \dots + a_{wn} X_n \leq b_w$$

where,

π = Aggregate net income from the crops (Rs.)

C_n = Net income per unit of the n^{th} crop (Rs.)

X_n = Area under n^{th} crop (Ha.)

b_1 = Land available for cultivation (Ha.)

b_m = Labour available for cultivation (Man Days)

b_k = Capital availability (Rs.)

b_w = Water availability (mm.)

a_{mn} = Amount of labour required for n^{th} crop (Man days)

a_{kn} = Average amount of capital required for n^{th} crop (Rs.)

a_{wn} = Amount of water required for n^{th} crop (mm.)

Selection of the typical farm :

The average size of holding, utilization of irrigation water, labour utilization, cash expenditure and net returns of all the farms in a particular situation was calculated and a farm which was very close to this average was taken as the typical farm for that situation. Thus, four typical farms were selected for each crop namely Maize, Banana, Tomato, Groundnut.

Input co-efficients :

For programming under actual farm situation, the input co-efficients included were the averages of all the farms surveyed in the region. These input co-efficients were considered for enterprise that was being adopted currently in the nodal farm.

Resource constraints :

In the area under study, the most restricting

resources identified were primarily irrigation water, besides land availability during the cultivating seasons and capital.

Land restrictions :

Land as a resource in a particular farm cannot be increased by way of purchase or lease at least in a short period. Hence, land was one of the most limiting factors to be considered in the formulation of the problem. The equality constraints were given based on the fact for that the area allocated to the crops.

Capital restrictions :

The capital requirement of the farmers was met by the credit facilities extended by the various institutions and borrowing from neighbours apart from their own resources. In the study area, the farmers were growing high value crops hence, capital was found to be a limiting factor.

Irrigation water restrictions :

Irrigation was identified as the crucial factor for cultivation of crops in the study region. In order to decide the critical periods of irrigation requirements, monthly requirements of irrigation water for different crops were estimated. the assumptions underlying this constraint is that water demand should; 1) match with water availability and 2) be decided on the basis of relative returns from crops using water.

Availability of resources and inputs :

Having estimated the resource requirements and identified the restricting resources, it was essential to assess the availability of resources. For compiling the resource availability the resources that were available in the typical farms selected were estimated from the survey data are taken into account.

RESULTS AND DATA ANALYSIS :

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

The existing and optimal crop plans :

Optimization of crop portfolio for the selected farm is a type of risk management strategy. For the present study, the farm similar to average farm size was selected

as a representative farm. For each crop, one farm similar to average farm size was selected as representative farm and optimized. The relative efficiency of the optimal plans and the existing plan is analysed in the following sections. Kalra and Singh (2000) concluded that optimization of water allocation and cropping pattern using a linear programming model was increased farm returns by 14.96 and 30.91 per cent, respectively in Megachappar and Mitali areas of Haryana state.

Optimal crop plan for Namakkal block :

The analysis of cropping pattern in the nodal farm could reveal that the existing plan consisted of four crops, viz., maize, brinjal, tapioca and black gram. In the existing plan, maize was cultivated over 0.78 hectares of land. Brinjal was grown in 0.54 hectares; tapioca and black gram were cultivated in 0.48 and 0.30 hectares, respectively. The net income was computed to be Rs.52905.02 from the area of 2.10 hectares (Table 1).

In optimal plan brinjal was having the area of 1.51 hectares. Area under this crop increased from 0.54 hectares to 1.51 hectares. However, area under tapioca declined from 0.48 hectares to 0.39 hectares. Both maize and black gram was removed from the optimal plan. Even two crops were removed from the optimal plan, the net

income of farm increased from Rs. 52905.02 to Rs. 60045.66. The net income of the farm was increased by Rs. 7140.64. There was small variation between land area in existing plan and optimum plan land area was declined by 0.20 hectares from 2.10 hectare to 1.90 hectares. The decline in gross cropped area by 0.20 hectares would imply relatively less pressure on land that would again indicate the sign of bringing in sustainability of the productive capacity of the land. Finally, the area under optimal plan declined from 2.10 hectares to 1.90 hectares which accounts 9.52 per cent, but the net income of the farm was increased .

Optimal crop plan for Mohanur block :

In the canal command farm, on an average, banana, paddy sugarcane and gram were grown in 1.32, 0.64, 0.69 hectares, respectively. The net income realized was Rs. 82404 in the existing plan (Table 2).

In the optimal plan, area for banana was declined from 1.32 hectares to 0.123 hectares. At the same time area for sugarcane was increased to 2.03 hectares from 0.69 hectares. In this case, paddy was removed from the optimal plan. The net income of the sample farm increased from Rs. 82404.40 to Rs. 94356.57. Even though the gross cropped area declined from 2.65 hectares

Table 1 : Optimal crop plan for Namakkal block

Sr. No.	Particulars	Season	Units	Existing area (ha)	Percentage to gross area	Optimal crop area	Percentage to gross area	Difference
1.	Maize	June-Sep.	ha	0.78	37.14	0.00	0.00	-0.78
2.	Brinjal	Oct.-Jan.	ha	0.54	25.71	1.51	79.47	+0.97
3.	Tapioca	Jan.-Dec.	ha	0.48	22.86	0.39	20.52	-0.09
4.	Blackgram	Jan.-Mar.	ha	0.30	14.29	0.00	0.00	-0.30
5.	Net income		Rs.	52905.02		60045.66		+7140.64
6.	Labour		Man days	220		220		0
7.	Capital		Rs.	29500.00		27418.65		-2081.35
8.	Water		mm	1500		1500		0
9.	Total farm size		ha	2.10		1.90		-0.20

Table 2 : Optimal crop plan for Mohanur block

Sr. No.	Particulars	Season	Units	Existing area (ha)	Percentage to gross area	Optimal crop area	Percentage to gross area	Difference
1.	Banana	Aug. - June	ha	1.32	49.80	0.123	5.58	-1.20
2.	Paddy	June - Sep.	ha	0.64	24.15	0.00	0.00	-0.64
3.	Sugarcane	Jan. - Dec.	ha	0.69	26.04	2.03	94.42	+1.34
4.	Net income		Rs.	82404.40		94356.57		+11952.11
5.	Labour		Man days	300		300		0
6.	Capital		Rs.	11000		11000		0
7.	Water		mm	4500		4428.89		-71.11
8.	Total farm size		Ha	2.65		2.15		-0.50

to 2.15 hectares in the optimum plan, the net income was marginally increased. During the critical period, irrigation water use had declined by 71.1 mm. Decline in the gross cropped area to 2.15 hectares as against 2.65 hectares in the existing plan would also indicate marginal reduction in the pressure on land.

Optimal crop plan for Tiruchengode block :

In the existing situation, the major crops like groundnut, sorghum, red gram were grown in 0.85, 0.34, 0.38 hectares, respectively. In the optimal plan, groundnut was removed from the plan *i.e.*, no area allocation was given for groundnut. Area under sorghum declined from 0.34 hectares to 0.02 hectares. But area under red gram increased from 0.38 hectares to 1.23 hectares. The gross cropped area under existing plan is reduced from 1.57 hectares to 1.25 hectares. The net income here increased marginally from Rs. 18513.92 to Rs. 23266.14. Even the income reduction, resources were efficiently used to get optimum pattern in this plan. Both water as well as human resources were used in their at most efficiency. Capital was also incorporated in its full efficiency.

Total cropped area was also declined from 1.57

hectares to 1.25 hectares. All the resource *viz.*, labour, capital, water were used as applied in the existing plan. There was a reduction of 20.38 per cent in gross cropped area in the optimum plan (Table 3).

Optimum crop plan for Pudhuchatram block :

In this existing situation, four crops namely tomato, sorghum, paddy, tapioca were grown in 0.94, 0.35, 0.63, 0.58 hectares, respectively. The net income realized was Rs. 51381.39 from this cropping pattern.

In the optimum plan, no area was allocated to tomato. Area under sorghum was declined from 0.35 hectares to 0.17 hectares. In case of tapioca, it was increased from 0.58 hectares 1.66 hectares. Area under paddy was declined from 0.63 hectares to 0.017 hectares. The net income was slightly increased from Rs. 51381.39 to Rs. 66447.15. Even though decline trend in net income, it showed that the resources which were used in the cultivation as an efficiency factor (Table 4).

Conclusion :

The study area Namakkal district of Tamil Nadu was purposively selected for the study because it comes

Table 3 : Optimal crop plan for Tiruchengode block

Sr. No.	Particulars	Season	Units	Existing area (Ha)	Percentage to gross area	Optimal crop area	Percentage to gross area	Difference
1.	Groundnut	Aug.-Nov.	Ha	0.85	54.14	0.00	0.00	-0.85
2.	Sorghum	June- Sep.	H	0.34	21.66	0.02	1.60	-0.32
3.	Red gram	June-Oct.	Ha	0.38	24.20	1.23	98.40	+0.85
4.	Net income		Rs.	18513.92		23266.14		+4752.22
5.	Labour		Man days	170		170		0
6.	Capital		Rs.	14000.00		13823.89		-176.11
7.	Water		mm	550		550		0
8.	Total farm size		Ha	1.57		1.25		-0.32

Table 4 : Optimal crop plan for Pudhuchatram block

Sr. No.	Particulars	Season	Units	Existing area (ha)	Percentage to gross area	Optimal crop area	Percentage to gross area	Difference
1.	Tomato	Oct.-Dec.	ha	0.94	37.60	0.00	0.00	-0.94
2.	Sorghum	May-Aug.	ha	0.35	14.00	0.17	9.19	-0.18
3.	Paddy	Sept.-Dec.	ha	0.63	25.20	0.017	0.92	-0.613
4.	Tapioca	Sept.-July	ha	0.58	23.20	1.66	89.73	+1.08
5.	Net income		Rs.	51381.39		66447.15		+15065.76
6.	Labour		Man days	300		298.7		-1.30
7.	Capital		Rs.	32100.00		31847.65		-252.35
8.	Water		mm	2000		2000		0
9.	Total farm size		ha	2.50		1.85		-0.65

under the category of dry land tract. In Namakkal district, blocks namely Namakkal, Mohanur, Pudhuchatram, Tiruchengode for each risky crop were purposively selected on the basis of area, production and productivity of those crops. Water was considered as the risky variable in the study area. Parashuram (2007) studied that the production loss estimates revealed that the losses due to droughts are more than floods and cyclones. He suggested some short term, medium term and long term policy measures to bring about stability in rice production. In the short term, the presently available drought tolerant varieties should be exploited through extension agencies. Also, government should take necessary steps to encourage crop insurance in all areas. In the medium and long term, government should encourage expanding tube well irrigation in Orissa, wherever it is feasible to combat the drought situation. These measures will not only stabilize rice production but also improve the poverty situation in the state.

Optimal crop plan for Namakkal block :

In the optimal plan the crop brinjal was having the area of 1.5 hectares. Area under this crop increased from 0.54 hectares to 1.51 hectares. However, area under tapioca declined from 0.48 hectares to 0.39 hectares. Both maize and Black gram was removed from the optimal plan. Even while two crops were removed from the optimal plan, the net income of farm marginally increased from Rs.52905.02 to Rs.60045.66.

Optimal crop plan for Mohanur block :

In the optimal plan, banana area declined from 1.32 hectares to 0.123 hectares. For sugarcane, area increased to 2.04 hectares from 0.69 hectares. But paddy was removed from the optimal plan. The net income marginally increased from Rs. 82404 to Rs.94356.57. Even though the gross cropped area declined from 2.65 hectares to 2.15 hectares in the optimum plan, the net income had marginally increased.

Optimal crop plan for Tiruchengode block :

In the existing situation, the major crops like groundnut, sorghum, red gram were grown in 0.85, 0.34, 0.38 hectares, respectively. In the optimal plan, groundnut was removed from the optimum plan. Area under sorghum declined from 0.34 hectares to 0.02 hectares and area under red gram increased from 0.38 hectares to 1.23 hectares. The gross cropped area under existing plan is

reduced from 1.57 hectares to 1.25 hectares. The net income here increased from Rs. 18513.92 to Rs.23266.14.

Optimum crop plan for Pudhuchatram block :

In the optimum plan, tomato was removed from the plan. Area under sorghum was declined from 0.35 hectares to 0.17 hectares. In case of tapioca, it was increased from 0.58 hectares to 1.66 hectares. Area under paddy was declined from 0.63 hectares to 0.017 hectares. The net income was slightly declined from Rs. 51381.39 to Rs. 66447.15. Even though decline trend in net income, it showed that the resources which were used in the cultivation as an efficiency factor.

Chavas (2008) studied that econometric analysis of state-contingent technology is possible and useful. He revealed that under risk aversion, the role of risk management in input choice can be important. The analysis provided evidence that technological progress has reduced the cost of production risk in U.S. agriculture over the last few decades. Research on management techniques for dry land agriculture like soil improvement, water conservation and water harvesting techniques need to be geared up to guard against nature's hazards. Diversification of enterprises like farming with dairy or any other suitable enterprises would offer a greater scope for stability in farm income of the study region provided it could be backed up with adequate financial support.

Authors' affiliations:

M. UMA GOWRI AND R. SANGEETHA, Department of Agricultural Economics, Tamil Nadu Agricultural University, COIMBATORE (T.N.) INDIA

LITERATURE CITED :

- Bhowmick, B.C. and Hazarika, C. (2007). Risk analysis and management in agricultural production – an experience of Majuli, the largest river Island of the World. *Indian J. Agric. Econ.*, **62**(3) : 544.
- Chavas, Jean-Paul (2008). A cost approach to economic analysis under state - Contingent production uncertainty. *Am. J. Agric. Econ.*, **90**(2) : 435-446.
- Heady, O. (1954). Simplified presentation and logical aspects of linear programming techniques. *J. Farm. Econ.*, **36**(5): 1035-1048.
- Kalra, B.S. and Singh, Iqbal (2000). Conjunctive use of surface water and ground water for cropping pattern optimization in head and tail reaches of Eastern Yamuna Canal Command Area in Western Uttar Pradesh. *Ann. Agric. Res.*, **21**(3) : 378-387.

Parashuram, Samal (2007). Natural calamities, rice production loss and risk coping strategies: The case of Orissa. *Indian J. Agric. Econ.*, **62**(3) : 529.

Report: Working Group on Risk Management in Agriculture

for XI Five Year Plan (2007- 2012).

WEBLIOGRAPHY :

<http://ifmr.ac.in/cirm/livelihood-agri.html>

★ ★ ★ ★ ★ ^{6th}Year of Excellence ★ ★ ★ ★ ★