FARM RISK MANAGEMENT THROUGH REDUCING WATER APPLICATION IN NAMAKKAL DISTRICT OF TAMIL NADU

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ABSTRACT:

Under different risky situations, farmers adjust his resource allocation not only based on its availability to maximize profit but also to avoid revenue loss. Based on this assumption, the present study was carried out in three different crops such as Maize, Banana and Groundnut from three blocks namely Namakkal, Mohanur and Tiruchengode of Namakkal district by taking the number of irrigations as risk. Main objectives were measuring the risk in farming with reference to cost of cultivation of the selected crops, to derive optimal input use under different risk farming situations and to determine optimal crop pattern under conditions of risk by an appropriate risk programming model. Quadratic production function which incorporated risk was used to measure the input choice under different risk situations. Linear Programming (LP) model used to derive the optimum crop choice under given risky condition. According to the quadratic production function outcome, the number of irrigation was 11 in normal condition and it reduced to 5 when farmer face risk in maize crop. Similarly irrigation was reduced from 33 to 23 for banana and 10 to 7 for groundnut crops in normal and moderate risk situations. Result of LP

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infers that optimal cropping plan of Namakkal block increased the farm income to Rs.8000. For other two blocks optimal plan allocates the resource efficiently for selected crops though it makes only a marginal difference in income. This study concludes adjusting input use is a way of managing revenue under risk farming.

KEY WORDS: Input use; Risk aversion; Risk management; Water management; Quadratic function.

1.0 Introduction

Agriculture in India is beset with a number of risks and uncertainties, which is mostly depends on the vagaries of nature (Bhowmick, 2005). Any decision pertaining to resource organization, allocation, production planning and enterprise selection are all important areas of farm decision making is risk inherent in every form of enterprise. But risk intensity in input-output relation in agricultural production is comparatively high. The presence of risks acquaints serious problems and hampers rational decision making in peasant agriculture. 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. It is important for all decision makers to know the degree of risk involved in each activity which a producer incorporate in his whole farm plan. Once the risk corresponding to an attainable level of expected return is known, depending on the risk taking ability and perceived risk, different farm plans having different level of risk can be taken up by different farmer. It is expected that farmers who would not like to bear higher risk would be satisfied with a lower but stable return. But those who have higher risk bearing ability would certainly go for maximizing expected net returns with available input and capital.

Farm plans to maximize the stability in farm income were also formulated for this purpose. This study is one such attempt to help farmers with specific suggestion to reduce risk, with emphasis on understanding the influence of farm risk on both internal and external capital rationing in farm business. In this context, the present study was taken up with the following objectives. They are,

i) To derive optimal input use under different risk farming situations.

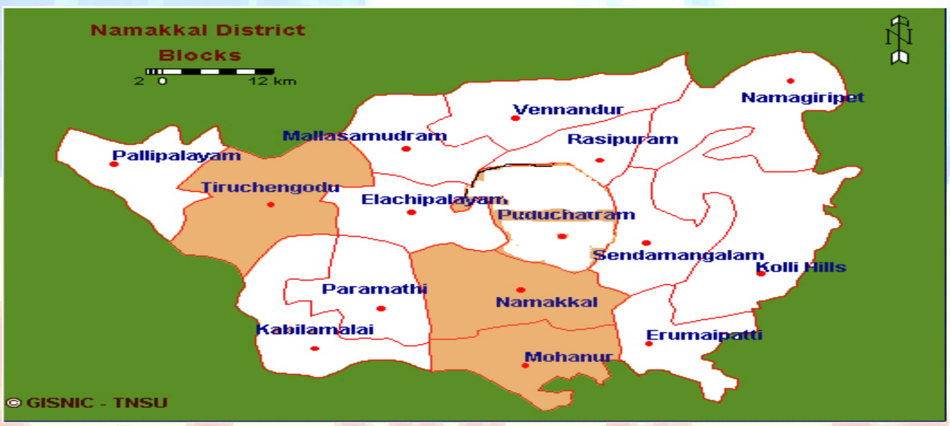
ii) To determine optimal crop pattern under conditions of risk by an appropriate risk programming model.

iii) To suggest policy measures for public and private players for managing risk.

2.0 Materials and methods:

2.1. Selection of the study area

The study was conducted in Namakkal district which was purposively selected based on the fact that it is drought prone area. Hence, the availability of exclusively dry farms was a main criterion. And another criterion which used while selecting the study area was availability of irrigation facilities, as water problem was considered an important risky variable that causes the drought. Three risky crops viz., Maize, Banana and Groundnut were selected in the respective three blocks of Namakkal, Mohanur and Tiruchengode. The selected block map was given in the Map 1.



Map 1: Namakkal district's Block map.

2.2. Sampling procedure

The sampling design followed in this study is a multi-stage purposive sampling design. In the first stage, four blocks namely Namakkal, Mohanur and Tiruchengode were purposively selected on the basis of area, production, productivity of the selected risky crops. In the second stage, from each block four villages were selected randomly by adopting the method of probability proportion to size in term of crop area. About ten farmers were selected from each of the four selected villages randomly in the last stage. Thus, 40 farmers were selected from each of the sample blocks which made up the total sample size to 120.

2.3. Data

The primary data required for the study were collected through personal interview with the help of interview schedules. The interview schedule for the farmers covered the aspects such as age, educational status, size of the family, asset position; cropping pattern, income and expenses were elicited. Details of cost of cultivation and income from crop activities and livestock were gathered to compute the farm income and expenses. To assess the risk bearing ability, information about off-farm and non-farm income were gathered. Besides these, information regarding credit requirements, credit availability, investment in the past years, total value of off-farm and non-farm assets and liabilities were collected. Secondary data were collected to assess the market and price risk associated with selected crops.

3.0. Tools of analysis

3.1. Production Function

Given that production is the process of combining resources, both implicit and explicit, in the creation of goods or services or output, the production function is defined as the mathematical description of the various technical possibilities faced by a firm. It defines the maximum physical output levels obtainable from various levels of inputs. Generally, a production function is defined as,

$$Y = f(X_1, X_2, \ldots, X_n) \qquad \ldots\ldots\ldots.(1.1)$$

Where

Y is output, X_i, i = 1,2,……n are the levels of X, through the mathematical relationship f. From an economist's point of view, expression (1) is taken as the basis for exposing economic principles, the analysis of which starts usually with a single input, keeping all other variable constant,

$$Y = f(X_1 / X_2, \ldots, X_n) \qquad \ldots\ldots\ldots\ldots(1.2)$$

Theoretical Quadratic Production Function

This is a specific case of the more general polynomial specification. The quadratic function in a two input case can be specified without an interaction term as,

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_1^2 + \alpha_4 X_2^2 \quad \text{..............(1.3)}$$

In which case it is inherently additive for the quadratic specification to have a meaningful interpretation as a production function, the conditions α_1, $\alpha_2 > 0$ and α_3, $\alpha_4 < 0$ should be satisfied. The marginal productivity of X_1 is $\alpha_1 + 2\alpha_3 X_1$ and that of X_2 is $\alpha_2 + 2\alpha_4 X_2$ and is not affected by the levels of other input.

Average productivity (APP) is given by dividing total output by input level, and is represented as,

$$APP = (Y/X_1) = f\,(X_1 / X_{2\ldots,} X_n) / X_1 \quad \text{……….…. (1.4)}$$

This gives information about the average output per unit of input applied, over the entire range of the inputs applied. Similarly, marginal productivity (MPP) is given by the derivative of the total output response function and is represented as

$$MPP = dY/dX_1 = df(X_1 | X_{2\ldots,} X_n)/dX_1 = f' \quad \text{..……….. (1.5)}$$

MPP gives information about the additional output response to an additional input change at the margin that is., incremental output to a given incremental change in input.

Physical optimum is derived by the relationship between Marginal Physical Product (MPP) and Average Physical Product (APP). But in case of economic optimum, it is derived equating Value Marginal Product (VMP) with Px.

Empirical Quadratic Production Function

Based on the above theoretical model, the following empirical quadratic function is derived and applied for each crop namely maize, banana and groundnut in the present study.

$$Y = \alpha 0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_1^2 + \alpha_5 X_2^2 + \alpha_6 X_3^2 \quad \text{..............(1.6)}$$

Where,

Y = Yield (Kg)

X_1 = Water use (No. of irrigation) or No. of Rainy days in the season.

X_2 = Labour (Man days)

X_3 = Fertilizer (Kg)

Differentiating Y with respect to X_1, marginal product as given

$$MPPx_1 = dY/dX_1 = \alpha_1 + 2\alpha_4 X_1 \quad \text{..............(1.7)}$$

Equating marginal product to inverse price ratio,

$$dY/dX_1 = Px_1 / P_y$$

$$P_y [dY/dX_1] = P_{X1}$$

$$P_Y [\alpha_1 + 2\alpha_4 X_1] = P_{X1} \quad \text{..............(1.8)}$$

Hence VMP = Px

Optimality was achieved when factor price was equated to the value of marginal product under risk neutral situations. This relationship was not true when the production process envolved risk. This model had been applied by Shanmugam and Palanisamy (1993) in the study related to water production functions under different risky production environment. Anderson *et.al.*, (1977) derived one factor – one product production function under risky situation. The given figure 1. Clearly illustrate the risk reduction under different input levels.

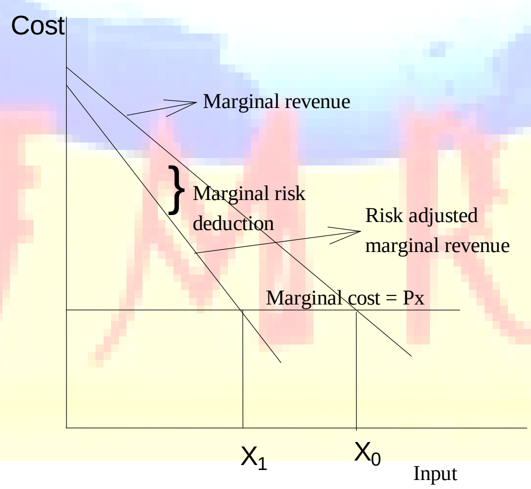


Figure 1: Risk reduction through input use.
Source: (Palanisami et al, 2002)

They established the following relationship to derive the optimal input use under risk.

$$Px_1 = Py\frac{d\hat{Y}}{dX_1} - REDQ\left[P_y^{\,2}\frac{dV(Y)}{dX_1}\right] \quad \text{..............(1.9)}$$

The term V(Y) denoted variance of crop yield. Can be denoted as It $V(Y) = Y - \hat{Y}$. The optimal input level occurred when the marginal factor cost was equal to the value of marginal product minus a marginal risk deduction that depended on the utility function. REDQ term in equation referred to risk evaluation differential quotient. Binswanger and Sillers (1983) defined the values of risk evaluation differential quotient for rural India.

Neutral : Zero

Slight aversion : 0.316 to zero

Moderate aversion : 0.812 to 0.316

3.2. Linear Programming

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 is maximization of net profit or cost minimization which 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 (profit maximization or cost minimization) is linear in form and constraints on resource restrictions are specified in linear form.

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:

$$\text{Maximize } \pi = C'X \qquad \ldots\ldots\ldots\ldots (2.1)$$

Subject to

$$AX \leq B \text{ or } AX \geq B \qquad \ldots\ldots\ldots\ldots (2.2)$$

$$X \geq 0 \qquad \ldots\ldots\ldots\ldots (2.3)$$

Where,

A is m Xn - matrix of technical coefficients

C is n X_1 - vector of prices or other weights for the objective function

X is n X_1 - vector of activities (crops and livestock to be produced which are unknown decision variables)

B is m X_1 - vector of resources or other constraints, availability in physical units, such as labour, land, etc ., and the objective function.

$$C'X = \pi, \qquad \text{............. (2.4)}$$

In expanded form it is written as:

$$\text{Maximize } \pi = C_1 X_1 + C_2 X_2 + \text{.........} + C_n X_n \qquad \text{............. (2.5)}$$

Subject to

$$a_{l1} X_1 + a_{l2} X_2 + \text{.........} + a_{ln} X_n \leq b_l \qquad \text{............. (2.6)}$$

$$a_{m1} X_1 + a_{m2} X_2 + \text{.........} + a_{mn} X_n \leq b_m \qquad \text{............. (2.7)}$$

$$a_{k1} X_1 + a_{k2} X_2 + \text{.........} + a_{kn} X_n \leq b_k \qquad \text{............. (2.8)}$$

$$a_{w1} X_1 + a_{w2} X_2 + \text{.........} + a_{wn} X_n \leq b_w \qquad \text{............. (2.9)}$$

where,

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

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

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

b_l = Land available for cultivation (Ha.)

b_m = Labour available for cultivation (Man Days)

b_k = Capital availability (₹.)

b_w = Water avilability (mm.)

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

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

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

4.0. Results:

4.1. Results of Production Function

From the results of the table 2, the average maize yield per hectare was 3503.10 Kg. The average number of irrigation required for maize per hectare was 10.20. The average price per kg of maize was ₹.7.93. The cost of one irrigation which included labour charges only was ₹.360.

The average banana field per hectare was 26057.37 Kg. The average number of irrigation per hectare was 31. The average price per Kg of banana was ₹.76. The cost of one irrigation which included labour charges only was ₹.240. The average yield of groundnut per hectare was 1750.83 kg. The average number of rainy days was 9.3. The average price per kg of groundnut was ₹.19. For groundnut the variable number of rainy days was selected as a risky variable. Rainy day is a day when rainfall exceeds 10mm or 1cm. Number of rainy days is decided by nature only. It is not controlled by human being. Also the cost of rainy days was determined as zero.

Table 1: Comparative statistics of different crops from the study area

Sl. No.	Variables	Banana	Maize	Groundnut
1.	Yield (Y) in t/ha	26.057	3.503	1.751
2.	Water (X_1) in numbers	33	11	10
3.	Labour (X_2) in man days	116.42	116.84	64.67
4.	All Fertilizers (X_3) in kgs/ha	1689.52	239.83	151.03

4.1.1. Results of Traditional Quadratic Production Function

From the co-efficient table 3, among the three taken factors water is the important factor which influence yield in banana and maize. The labour has greatest influence on maize crop. Though fertilizer has considerable effect on all the crops groundnut is the most affected crop being dependent on gypsum for pod development. The estimated production function revealed the law of diminishing return for all the factors as evidenced from the sign of square term. It infers that, as we increase the number of units of factors (variables) the Marginal productivity decreases. Total number of samples was 40 in each crop.

Table 2: Result of Quadratic production function

Sl. No.	Variables	Banana	Maize	Groundnut
1.	Intercept	17460.74 (54)	2469.45 (68)	1306.42 (27)

2.	Water (X_1)	164.15 (4.16)	158.04 (3.13)	0.16 (3.14)
3.	Labour (X_2)	32.85 (73)	28.34 (4.17)	7.34 (4.07)
4.	Fertilizer (X_3)	19.37 (53)	12.57 (22)	20.35 (4.20)
5.	Water X Water (X_1^2)	-1.52 (-27)	-5.12 (-36)	-0.008 (-4.76)
6.	Labour X Labour (X_2^2)	-1.48 (-4.01)	-0.04 (-2.97)	-0.46 (-35)
7.	Fertilizer X Fertilizer (X_3^2)	-0.005 (-2.92)	-0.10 (-95)	-0.05 (-57)
8.	R^2	0.48	0.28	0.29
9.	N	40	40	40
10.	F	130.96	95.86	0.92

* Values given inside the brackets are 't' statistics at 1% significant level

4.1.2. Results of Quadratic Production Function Incorporating Risk

Three factors of production such as water, labour and fertilizer were used for the traditional production function. For describing the input use under risky situation only one input that is water application (number of irrigation is used). As a drought prone area water scarcity was the main constraint faced by the farmers. Hence, number of irrigation under different risk level was taken into consideration for further research.

Optimal input use under different risk averse conditions

The table 4, shows that the optimal number of irrigation which was required for each risk aversion level. As number of irrigation decreases with different risk situations, MPP increases. In other words, MPP is diminishing at second region of the production function curve.

4.1.2.1. Optimal water use under different risk averse conditions for Maize

The optimal number of irrigation, under normal condition (neutral risk) was worked out to be 11 for Maize in Namakkal block. It was reduced to 9.7 since the decision maker was slightly averse to risk. And it further reduced to 4.9 under moderate risk averse situation (Table 4.). Comparing this value to optimal input use under slight aversion to risk, the number of irrigation was decreased as the co-efficient of risk aversion increased.

Table 3: Optimal Number of irrigation for different risk aversion levels

Sl. No.	Risk Situations	Maize	Banana	Groundnut
1.	Neutral Risk	11.00 (45.40)	33.00 (673.00)	10
2.	Slight Risk Aversion	9.71 (58.61)	30.11 (72.62)	9.20
3.	Moderate Risk diversion	4.88 (108.07)	23.61 (92.38)	7.43

Note: Parentheses given inside the brackets are MPP values of irrigation.

The figure 2, explains the Value Marginal Product (VMP) of optimal number of irrigation was kept decreasing in all the risk averse (Neutral, Slight and Moderate risk) levels. This figure illustrate clearly that risk neutral condition with higher input application (11 irrigations from table 4.) will yield high return to the farmers and in contrast Moderate risk with lowest input application (5 irrigations) which provide lowest return to the farmer.

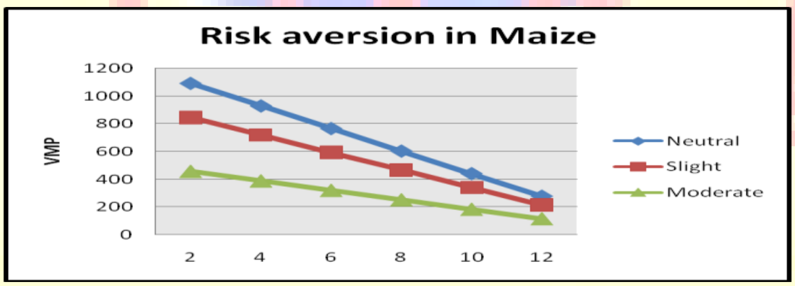


Figure 2: VMP at different risk averse conditions for Maize.

4.1.2.2. Optimal water use under different risk averse conditions for Banana

The optimal number of irrigation per hectare under neutral risk situation was 33 which was higher than 31 under normal condition. The optimal number of irrigation was reduced from 33 to 30 since the decision maker was slightly averse to risk. Comparing to optimal input use under slight aversion to risk, the number of irrigation was still decreased to 23.61 as the co-efficient of risk aversion increased to moderate (Table 4.).

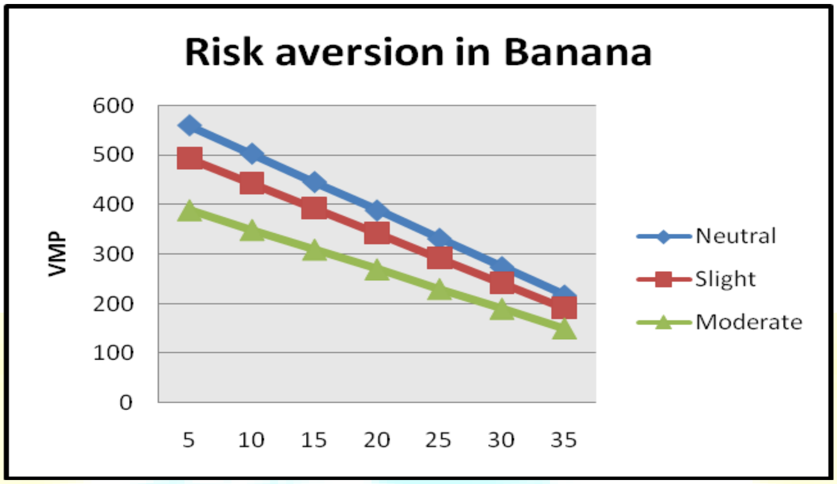


Figure 3: VMP at different risk averse conditions for Banana.

The figure 3, explains the Value Marginal Product (VMP) of optimal number of irrigation was kept decreasing in all the risk averse (Neutral, Slight and Moderate risk) levels. From the figure it can be understood that high risk condition has the lowest input level 24 irrigations. VMP of this moderate risk is comparatively low because of this lowest input use. Slight risk condition has lower input level than neutral and higher than moderate risk level. And the risk neutral condition with higher input application (33 irrigations from table 4.) has the highest MP value.

Thus this figure explains clearly about the psychological concept that is, when risk level is increased the farmer reduces his factor application to avoid loss and protect himself within the threshold level of cost, was proved by this research

4.1.2.3. Optimal water use under different risk averse conditions for Groundnut

The optimal number of rainy days under normal condition (neutral risk) was worked out to 10. The optimal number of rainy days under neutral risk situation was higher than the average number of rainy days. In this case, the decision maker expected rainy days was 9.20 under slight risk situation. The decision maker expected rainy days was 7.43 under moderate risk situation (Table 4.).

Being wholly dependent on rainfall the groundnut crop in the Tiruchengode block was completely a rainfed crop. So the number of rainy days has been taken as a risky variable. Marginal cost of irrigation is zero. The figure 4, shows that when the rainfall fails the VMP goes negative. Under normal rainfall (neutral risk) condition the VMP goes down as we increase the number of input application.

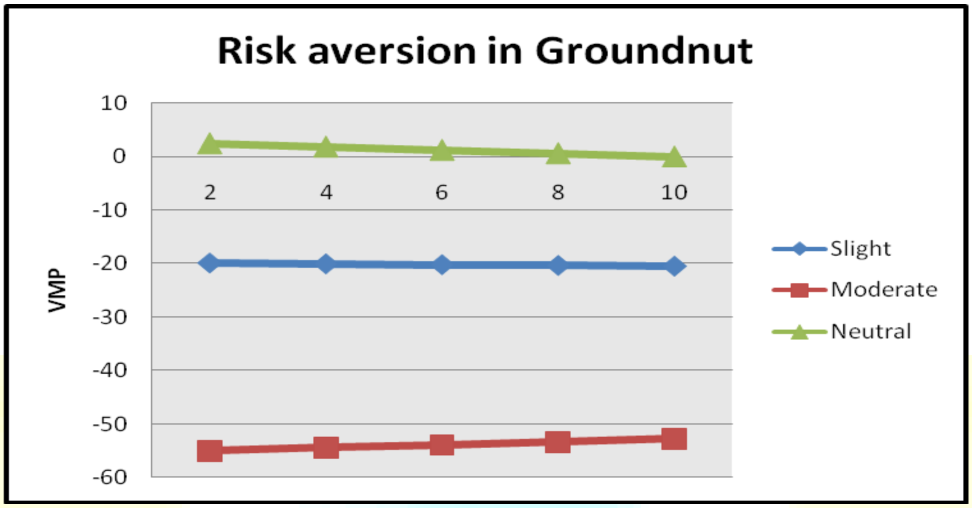


Figure 4: VMP at different risk averse conditions for Groundnut.

Risk management in agriculture range varies from informal mechanisms like avoidance of highly risky crops, diversification across crops and across income sources to formal mechanisms like agriculture insurance, minimum support price system and future's markets. 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, favor traditional techniques over modern technology and enter into share-cropping arrangements (Report: XI five Year Plan, 2007-2012). The results of quadratic production function concluded that when risk level increases, optimum quantity of inputs used for the production has decreased. It tends to increase in MPP value for each risk situation. As number of irrigation decreases with different risk situations, MPP increases. It denotes the first phase of production function. Hence there is chance to further increase in production (profit) by changing the resource allocation.

4.2. Results from Linear Programming model

Table 5, compares the nexus between existing crop plan in all the three blocks and the optimal plan which was worked out by Linear Programming model. The result of the table 5 was explained below.

Table 4: Comparison of Existing plan and optimal cropping plan

Area in ha

Block	Crop	Existing Area	Optimal Crop Area

Namakkal	Maize	0.78	0.00
	Brinjal	0.54	1.51
	Tapioca	0.48	0.39
	Black gram	0.30	0.00
	Net Income (₹.)	**52905.02**	**60045.66**
Mohanur	Banana	1.32	0.123
	Paddy	0.64	0.00
	Sugarcane	0.69	2.03
	Net Income	**82404.40**	**94356.57**
Tiruchengode	Groundnut	0.85	0.00
	Sorghum	0.34	0.02
	Red gram	0.38	1.23
	Net income	**18513.92**	**23266.14**

1. 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 ₹.52905.02 to ₹.60045.66 (Table 5). It is necessary to reduce the total area under water scarcity condition.

2. 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 2.03 hectares from 0.69 hectares. Paddy was removed from the optimal plan being a high water demanding and less income supplying crop. The net income marginally increased from ₹. 82404 to ₹.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 (Table 5).

3. 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 ₹. 185192 to ₹.23266 (Table 5).

The results of this research were provided by taking the study period cost and prices for analysis. These results may not be appropriate for the other dynamic studies which have different input costs and product prices. But it can be generalized for other areas those have similar drought and cropping pattern condition.

5.0. Conclusions

The following conclusions could be drawn from the results of the study.

- This study concludes that farmers adjust their input application not only according to its availability and also based on different risk levels they are ahead of facing. If the risk is high they reduce their input use to avoid loss in the profit. Hence, input use is one of the easy choices for the harder situations in the dryland farming.
- Quadratic production function results concluded that when risk level increases, optimum number of inputs used for the production was decreased so that the revenue loss can be averted. It concluded that as number of irrigation decreases, MPP value at each risk aversion level was increased which means the under usage of available resources. So, it denotes that the possibility of reallocation of resources for efficient utilization and attains the profit maximum.
- From the result of LP models it was evidently proved that there is further chance to reallocate the resources efficiently to maximize the profit. In the optimal plan of Namakkal block, higher profit of ₹. 7140 can be achieved even after removing two crops that is maize and black gram. The increased net return from high sugarcane area was ₹.11950. In addition to the increase in income the resources also were efficiently used in the optimum cropping pattern.
- In the light of the results of risk quadratic function, it can be understood that the recourses were not properly utilized in the study area. The vagarious of nature lead to poor utilization of resources in the fear of losing revenue. And the LP model appended

the fact by giving optimal plan for maximizing revenue through reallocating the given resources for each block.

Policy implications

Being influenced by many factors such as climatic variation, water and labour scarcity, farming is considered as a non profitable and unsustainable occupation especially in dry tracts. It is essential to take the necessary steps for making the farming as profitable and to stop the farmers who impend to leave the farming. Based on the above analysis and conclusions the following policy options could be discerned.

- ❖ Forecasting the impending climatic occurrences at proper time will help the farmers in their decision making. Increasing awareness among farmers to utilize resource effectively instead of using less may result in both effective resource employment and achieving more profit.
- ❖ Crop insurance can be introduced to cover high risk zones. The insurance scheme, covering the enterprise mix as derived from the alternative plans to stabilize the income could be considered. Government may subsidize the premium rate for small farms especially in the rain fed situation.
- ❖ Crop centered diversification could be resorted through the choice of crops with varying maturity periods, differential sensitivity to environmental fluctuations. 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.

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