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Research Article

Developing Risk Efficient Farm Plans Under Different Dry Farming Situations in Semi Arid Tracts of Ariyalur District, Tamil Nadu- A Programming Approach

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ABSTRACT

The present study focuses on developing the risk efficient farm plans for the rain fed farms across scale of farming in Ariyalur district. The farmers were stratified into small, medium and large farms based on farm size. The farm plans include both crop and animal husbandry enterprises. The optimum plans were derived for each size group of the farms using the MOTAD risk programming model and the existing plans were parameterized for capital and gross income and three plans were derived and compared with the existing farm plan. The results revealed that plan I for small dry farms was superior compared to other plans, with a gross income of Rs.14534 and the mean absolute deviation income of Rs.1853.42. With respected to medium dry farms, Plan III was found superior with a gross income of Rs. 28908.00 and an income variability of Rs. 5980.70. As regards the large dry farms, plan II was proved to be the best and the gross income and income variability were Rs.48840 and Rs.3726.51, respectively. The E-A frontiers involving plan I to Plan III for all the three modal farms were plotted and it concurrently coincides with the theory that as the expected income increased risk also increased. The E-A frontier for small farm is less steep, showed a weakened trade -off between expected income and income variability, indicating the susceptibility of small farms to risk and its steepness towards the end of frontier indicated the need for bridging the credit gap fully, so as to minimize the risk and to improve its income. The E-A frontier for medium farm is steeper than small farm, indicating better risk assumption capacity and expanding credit in medium farm would decrease the risk of income variability. The E-A frontier for large farms was steeper than small and medium farms, indicating the sound risk assumption nature of large farms and expansion of credit would still improve its ability to minimize the income variability.

Keywords: *Income variability, Rain fed farms, Optimum plans, Linear programming, Absolute deviation, MOTAD and, E-A frontier.*

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INTRODUCTION

Agriculture is the primary occupation for most of the population in India, as it provides employment to 58 per cent. Dry land agriculture plays an important role in meeting out the growing food demand. Nearly 58 per cent (80 million hectares) of net sown area in India is under rain fed agriculture. Rain fed agriculture contributes 40 per cent of the total food production in India. Tamil Nadu is one of the water starved state, which is endowed with only 3 per cent of the available water of the nation. Ariyalur is one of the most backward dry farming districts in Tamil Nadu. Dry farming is mainly carried out in most of the areas of the district due to insufficiency of irrigation water. Out of the six blocks in the district, four blocks are predominantly rain fed, where dry farming is practiced. The full yield potential of this rain fed areas was not tapped adequately and there exists scope of bridging the yield gap in this dry land to a greater extent. In order to meet the growing food demand in this district, the productivity under rain fed farming should be increased with the help of dry land technologies coupled with water harvesting efforts. With is end in view, the present study was undertaken with the main focus of developing risk efficient optimum farming plans across scale of farming to help the rain fed farmers with different resource endowments in the study area.

Objective

1. To develop risk efficient dry farming plans with optimum enterprises mixes.

MATERIALS AND METHODS

Sampling design

Ariyalur district was selected purposively, as it is one of the major dry farming districts of Tamil Nadu. A three stage random sampling procedure was adopted to select the respondents. At the first stage, all the six blocks in Ariyalur district namely Ariyalur, Thirumanur, Jayankondam, T. Palur, Sendurai and Andimadam were arranged in the ascending order based on proportion of area under rain fed crops to gross cropped area in 2018-19 and four blocks with maximum proportion under rain fed crops namely Ariyalur, Sendurai, Jayankondam and Andimadam were selected. Using the same criterion, all the revenue villages in the selected blocks were arranged and two revenue villages each per block were selected at random, thus a total of eight revenue villages were selected in the second stage. At third stage, all the dry farmers in each selected villages were arranged alphabetically and 20 farmers per village were selected, thus making the sample size as 160 farmers. The selected farmers were post stratified according to the farm size as small, medium and large farmers for further analysis.

MOTAD –Minimization of Total Absolute Deviation

Linear programming is widely recognized as a method for determining a profit maximizing combination of farm enterprises that is feasible with the fixed linear farm constraints. The conventional deterministic model ignores uncertainty and it is unacceptable to the rain-fed farmers in the practical world. Though farmers try to maximise their annual net farm returns, they also concerned about minimizing the risk in rain fed farming. Farmers combine different farm enterprises by considering the risk-return trade-off among different farm enterprises. They try to choose the combination based on their past experience, asset position entrepreneurship and the like. Farmers often would like to stabilise their farm income or minimise the income variability, thus introducing risk in programming model is essential to make the results more relevant and useful.

In the present study it was considered appropriate to use MOTAD model (parametric risk programming) developed by Hazell, to derive risk efficient farming plans with enterprise combinations. MOTAD model uses the expected income (E) and mean absolute deviation (A) criterion. Mean absolute deviation in income were assumed to represent risk. The model proposed by Hazell to develop efficient set of farm plans with optimum enterprise mix and used in the study is presented below:

The absolute income deviation is the absolute value of gross margin deviation around the expected return. Total absolute deviation which accounts for both positive and negative deviations must be equal to zero and it shows that total positive deviations must be equal to total negative deviations. Hence, a model based on minimizing only the sum of absolute value of negative deviation also leads to the minimisation of total absolute deviation.

The formulation of MOTAD is given as follows:

Minimise $\sum_{t=1}^{s} \bar{Y}_t$ (1)

Subjected to

$$\sum_{j=1}^{n}(C_{ti} - g_i)\, X_i + \bar{Y}_t \geq 0 \quad (2)$$

for all t, t = 1 ……s

j, j = 1 ……n

and,

$$\sum_{j=1}^{n} f_i X_i = \lambda \quad (3)$$

for all λ, λ = 0 to ∞

$$\sum_{j=1}^{n} a_{ij} X_{ij} \leq b_i \quad (4)$$

for all i = 1, 2, ……m

for all j = 1, 2, ……n

$$X_j,\ \bar{Y}_t \geq 0 \quad (5)$$

for all t , j

where,

X_j	=	level of j^{th} activity,
$\bar{Y}_t$	=	Absolute value of negative net income deviation in year t,
$(C_{tj} - g_j)$	=	Deviation in net income for the year t and the activity j,
f_j	=	Expected net income of the j^{th} activity,
a_{ij}	=	Technical requirements of the j^{th} activity for the i^{th} resource or constraint,
b_i	=	level of i^{th} resource or constraint,
N	=	number of activities,
M	=	number of constraints,
S	=	number of years for which income deviations were incorporated, and
λ	=	a scalar representing level of expected net farm income.

The results when plotted on a graph would give expected income (E) - Mean absolute deviation (A) and it is called as E-A frontier. The E-A frontier generated by the above model would indicate the tradeoff between income and income variability, explaining how far the risk could be minimized, while attempting to maximize the income. The established results would show that the value of total absolute negative deviation of income was equal to the total positive deviation in income.

In the present study, the temporal data on yield and prices for different crops were collected from the CCPC scheme operated in the study area pertaining to the period 2013-14 to 2017-18. The data collected were panel in nature and representing the study area adequately. It was assumed that the representative farm selected for programming would follow the same yield and price deviation (for crop, live stock, off farm and non-farm activities) of the CCPC samples. The CCPC data considered for the study were from selected CCPC villages in the period between 2013-14 and 2017-18 in the study area The E-A frontier generated by the above model was used to evolve the optimum

enterprise combinations which would minimise the risk by minimizing the income variability and at the same time maximise the income. The established results would show that the value of total absolute negative deviation of income was equal to the total positive deviation in income.

$$\sum Y_t^- = \sum Y_t^+ \quad (6)$$

But the total absolute deviation is

$$S A = \sum Y_t^- + \sum Y_t^+ \quad (7)$$

where A = mean absolute deviation in income

S = number of years

Therefore it would follow that

$$\sum \bar{Y}_t = \frac{1}{2} S A, \text{ and}$$

$$A = \frac{\sum \bar{Y}_t}{1/2\, S} \quad (8)$$

Hence, to know the mean absolute deviation in income, the total negative income deviation is divided by half the value of number of years considered for the study.

The simplex method was used to derive optimum combination of enterprises. TORA Ver. 1.0 was used for programming and to derive risk efficient farm plans for different modal farms situation.

Selection of Modal Farms:

The representative farms were selected for each size group (small, medium and large farms) by working out first the mean of the farm size, gross income, net margin, number of enterprises, asset position and credit availability of all the farms selected in each of the category and then selecting a particular farm in that category as the modal farm which lies very close to the mean of all the variables given above.

RESULT AND DISCUSSION

Optimum plans

Three risk efficient optimum plans were derived for each of the selected modal farm. Plan I has been drawn with the existing level of resources and income while in plan II & III, credit gap was relaxed by 50 per cent and 100 per cent, respectively, and by parameterising income levels to study the effect of increase in credit availability on income variability and expected income in different categories of farms.

Optimum plan for small farmers

The optimum plans derived along with existing plan for small dry modal farm situation are presented in Table 1. The existing plan for small dry modal farm had a gross cropped area of 1.01 ha with 0.61 ha of groundnut, 0.80 ha of maize, 0.60 ha of cotton, 2 numbers of goats, 31 man days off-farm employment and 20 man days of non-farm employment. The existing plan had incurred a variable cost of Rs.9259.54 with an income of Rs.14534.00. The mean absolute deviation in income associated with the existing plan was Rs.4143.77. It could be observed from the results that, the mean absolute deviation in income in optimum plan I was reduced to Rs.1853.42 from Rs. 4143.77 when compared to the existing plan with the maintenance of existing income. This may due to the inclusion of new enterprises such as cumbu, black gram and poultry along with existing enterprises maize and cotton, with minimum income variability and replacement of goats with poultry. The off-farm employment was also reduced when compared to existing plan. The plan I also resulted in a saving of about 18 per cent in the variable cost as compared to the existing plan. Though plan II has increased the expected income marginally as compared to plan I, the mean absolute deviation in income was increased to Rs.3473.54. The plan reduced the cost by six per cent and generated an additional income of only about eight per cent when compared to existing plan.

As regards plan II, cotton was completely eliminated and area under black gram decreased. Area under maize had increased to a larger extent, while cow and goat enterprises were included. Though, there was not much difference existed between plan I and plan II with respect to expected income, the mean absolute deviation in income was found to the very high in the plan II. The enterprise mix, off-farm and non-farm employment also did not show much variation between the two plans.

The results revealed that in small dry farms, by augmenting the credit supply, the income could be increased with a reduction in risk, indicating the dire need of enhancing credit supply. Considering the increase in the level of expected farm income and corresponding level of mean absolute deviation in income, plan I was found to be superior with more reduction in the variable cost. From the above analysis it is evident that the mean absolute deviation in income could be reduced to a larger extent without sacrificing the existing income, by including poultry and cotton.

Table 1: Optimum plan for small dry farms

S. No.	Particulars	Existing system mix	Optimum system mixes		
			Plan I	Plan II	Plan III
1.	Expected farm income in rupees (E)	14534.00	14534.00	15846.00	15970.00
2.	Mean absolute deviation in income in rupees (A)	4143.77	1853.42	3473.54	3901.87
3.	Total variable cost in rupees	9259.54	7824.76	8739.81	9029.71
4.	Added cost in rupees	--	-1434.78 (-18.00)	-519.73 (-6.00)	-229.83 (-3.00)*
5.	Added return in rupees	--	0 (0.00)	1312.00 (8.00)	1436.00 (9.00)*
6.	**Crop enterprises** **Rain fed:**				
	i. Groundnut	0.61	0.19	0.27	0.27
	ii. Cumbu	--	0.05	0.07	--
	iii. Maize	0.80	0.23	0.57	0.43
	iv. Cotton	0.60	0.26	--	0.21
	v. Gingelly	--	--	0.27	0.42
	vi. Black gram	--	0.24	0.15	--
	Gross cropped area	1.01	0.97	1.33	1.33
7.	**Livestock enterprises**				
	Number of cow	--	--	6.00	5.00
	Number of goat	2.00	--	2.00	2.00
	Number of poultry	--	10.00	--	--
8.	**On-farm employment**				
	i. Man days	29.00	42.38	97.18	102.45
	ii. Woman days	13.00	37.31	51.31	42.31
9.	**Off-farm employment**				
	i. Man days	31.00	8.31	8.31	7.17
	ii. Woman days	--	6.22	6.22	--
10.	**Non-farm employment**				
	i. Man days	20.00	10.40	10.43	6.49
	ii. women days	--	4.00	4.31	--
	Credit requirement	8920.00	8920.00	10095.00	10540.00

The E-A Frontier derived for small dry farm is presented in Fig.1.

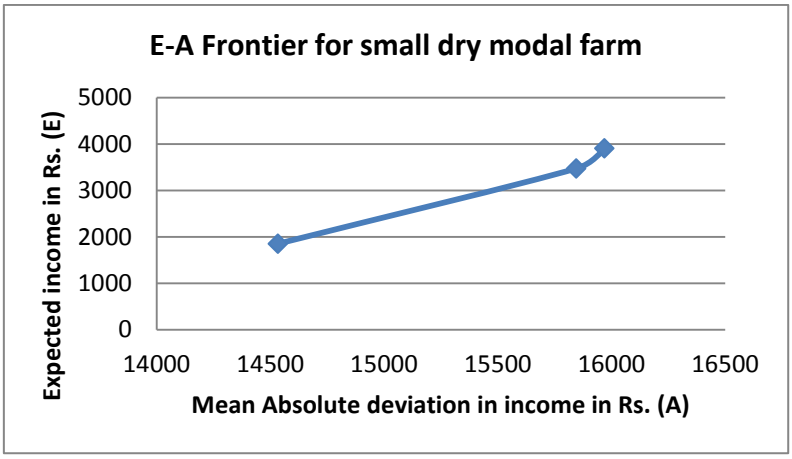

Fig. 1: E-A Frontier for Small Dry Modal Farm

The Frontier had positive slope which was less steep, showed a weakened trade -off between expected income and income variability, indicating the susceptibility of small farms to risk and its steepness towards the end of frontier indicated the need for bridging the credit gap fully, so as to minimize the risk and to improve its income. It concurrently coincides with the theory that as the expected income increased, the absolute deviation also increased.

Optimum plan for medium rain fed farms

The optimum risk efficient plans derived along with the existing plan for medium dry farm are presented in Table 2. The existing plan for medium dry modal farm had a gross cropped area of 2.83 ha with 0.80 ha of rain fed groundnut, 0.44 ha of rain fed cumbu, 0.71 of rain fed maize, 0.57 ha of cotton, and a herd of 11 goats. The existing plan had an income of Rs.28908.00 with a mean absolute deviation in income of Rs.5240.70. The total variable cost associated with the existing plan was Rs.14261.84.

It could be seen from Table.2 that the mean absolute deviation of income for all the three optimum plans were less than the mean absolute deviation in income of the existing plan, but it increased from Rs.4210.20 in plan I to Rs.5970.71 in plan III. New enterprise such as rain fed paddy has entered in the optimum plan I. Plan II and Plan III had an added return of 23.25 per cent and 31.87 per cent respectively, over the existing plan. The variable cost was reduced by 30.00 per cent in plan I, 16.00 per cent in plan II and 37.00 per cent in plan III, as compared to the existing plan.

Cumbu was completely eliminated in the optimum plans, while paddy, paddy + green gram and black gram were added. The area under groundnut showed an increasing pattern across the optimum plans I to III derived and also entered in all the plans. Goat population exhibited an increasing pattern from plan I to plan III, while cow was entered in plan I and plan III. Off-farm and non-farm men employment entered in all the optimum plans, while off-farm women employment entered only in plan II and non-farm women employment entered only in plan III. On-farm employment of family men and women increased significantly in all three optimum plans.

A comparison of the three optimum plans with respect to expected income, mean absolute deviation in income and variable cost revealed the superiority of plan III over the other optimum plans, since in plan III, the added return and reduced cost were higher with minimum income variability than other plans. The above analysis indicated that inclusion of a herd of 10 goat and 2 cows, crop enterprises such as groundnut, maize, cotton, paddy + green gram and black gram with additional credit would reduce the mean absolute deviation in income without foregoing the expected income.

Table 2: Optimum plan for medium dry farms

S. No.	Particulars	Existing system mix	Optimum mixes		
			Plan I	Plan II	Plan III
1.	Expected farm income in rupees (E)	28908.00	28908.00	35628.00	38122.00
2.	Mean absolute deviation in income in rupees (A)	5980.70	4210.20	5548.02	5970.71
3.	Total variable cost in rupees	14261.84	10034.26	12030.41	9047.62
4.	Added cost in rupees	--	-4227.58 (-30.00)	-2231.43 (-16.00)	-5214.22 (-37.00)
5.	Added return in rupees	--	0 (0.00)	6720.00 (23.25)	9214.00 (31.87)*
6.	**Crop enterprises** **Rain fed:**				
	i. Groundnut	0.80	0.71	0.73	0.77
	ii. Cumbu	0.44	--	--	--
	iii. Maize	0.71	0.20	--	0.52
	iv. Cotton	0.57	0.61	0.13	0.16
	v. Paddy	--	0.23	0.32	--
	vi. Paddy + green gram	--	--	--	0.27
	vii. Black gram	0.31	0.27	--	0.14
	Gross cropped area	2.83	2.02	1.18	1.86
7.	**Livestock enterprises**				
	Number of cow	--	1.00	--	2.00
	Number of goat	11.00	5.00	6.00	10.00
8.	**On-farm employment**				
	i. Man days	87.42	102.30	172.63	210.00
	ii. Woman days	23.00	85.61	97.12	112.51
9.	**Off-farm employment**				
	i. Man days	--	12.09	12.09	11.62
	ii. Woman days	--	--	8.43	--
10.	**Non-farm employment**				
	i. Man days	--	18.42	14.21	10.78
	ii. women days	--	--	--	6.03
9.	Credit requirement in rupees	9629.46	9629.46	12036.27	10995.16

The E-A Frontier derived for medium dry farm is presented in Fig.2.

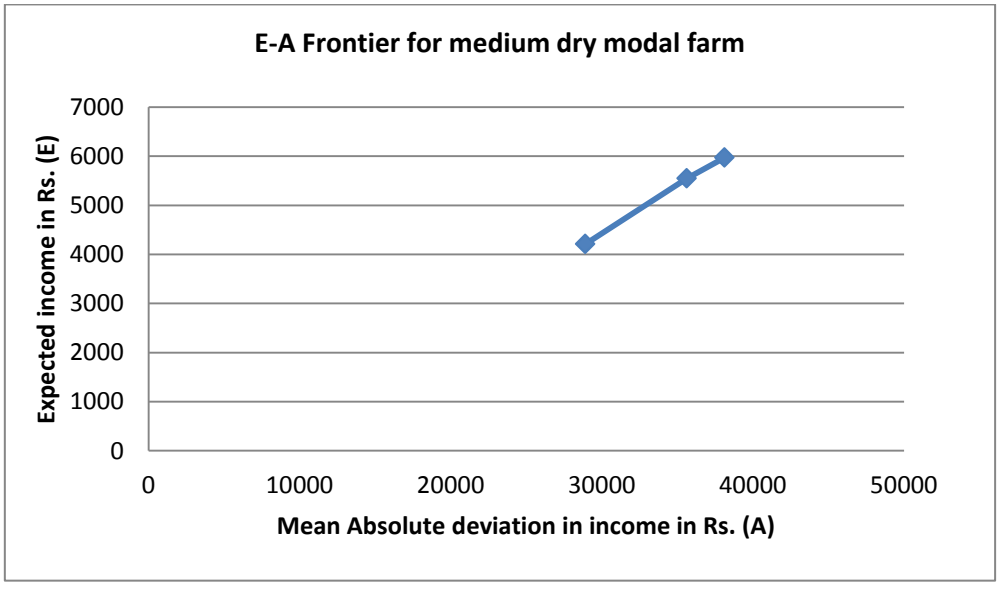

Fig. 2: E-A Frontier for Medium Dry Modal Farm

The E-A frontier for medium farm is steeper than small farm, indicating better risk assumption capacity and expanding credit in medium farm would decrease the risk of income variability. It concurrently coincides with the theory that as the expected income increased, the absolute deviation also increased.

Optimum plan for large rain fed farms

The optimum plans derived and the existing plan for large dry modal farm is presented in Table 3. The existing plan for large dry modal farm had a gross cropped area of 7.29 ha with 2.30 ha of cashew nut, 1.75 ha of rain fed groundnut, 0.80 ha of rain fed grain cotton, 1.07 ha of black gram, 1.37 ha of gingelly and 82.71 woman days of non-farm employment. The plan had an income of Rs. 41460.00 with mean absolute deviation in income of Rs. 8162.10. The total variable cost associated with existing plan was Rs. 20305.60.

The mean absolute deviation in income for all the three optimum plans were less than the mean absolute deviation in income of the existing plan, but it increased from Rs.2037.17 in plan I to Rs.4604.15in plan III. New enterprises such as rain fed maize, paddy milch animal and goat had entered the optimum plans, while cotton and gingelly were totally eliminated. Non-farm men employment entered the optimal plans, but it shows decreasing trends among the plans, while the off-farm man days were completely eliminated in optimal plans. On-farm family labour use increased for both men labour and women labour. The area under paddy and black gram showed a declining pattern across the optimal plans. Plan II and Plan III had an added return of 18 per cent and 27 per cent, respectively, over existing plan, while the variable cost decreased by 6.00 per cent in plan I and increased by 5.00 per cent in plan II and 27.08 per cent in plan III.

A comparison of added cost, added return and mean absolute deviation in income of the three optimum plans indicated the superiority of plan II over other plans, where per rupee return was more with minimum income variability. The above analysis indicated that inclusion of 5 cows, herd of 15 goats, cashew nut, groundnut, maize, paddy, black gram and non-farm men and women employment with additional credit supply would reduce the mean absolute deviation in income without foregoing the expected income in large dry farms.

Table 3: Optimum plan for large dry farms

S. No.	Particulars	Existing system mix	Optimum mixes		
			Plan I	Plan II	Plan III
1.	Expected farm income in rupees (E)	41460.00	41460.00	48840.00	52602.00
2.	Mean absolute deviation in income in rupees (A)	8162.10	2037.17	3726.51	4604.15
3.	Total variable cost in rupees	20305.60	19105.25	21271.15	25805.62
4.	Added cost in rupees	--	-1200.35 (-6.00)	965.55 (5.00)	5500.02 (27.08)*
5.	Added return in rupees	--	0 (0.00)	7380.00 (18.00)	11142.00 (27.00)*
6.	**Crop enterprises** **Rain fed:**				
	i. Cashew nut	2.30	0.90	2.27	1.35
	ii. Groundnut	1.75	0.84	0.62	0.87
	iii. Maize	--	0.56	1.69	1.56
	iv. Cotton	0.80	--	--	--
	v. Paddy	--	--	0.80	0.32
	vi. Black gram	1.07	0.42	0.15	--
	vii. Gingelly	1.37	--	--	--
	Gross cropped area	7.29	2.72	5.53	4.10
7.	**Livestock enterprises**				
	i. Number of cow	--	3.00	5.00	1.00
	ii. Number of goat	--	10.00	15.00	--
8.	**On-farm employment**				
	i. Man days	39.00	112.50	197.00	201.95
	ii. Woman days	29.00	80.34	89.71	94.54
9.	**Off-farm employment**				
	i. Man days	42.00	--	--	--
	ii. Woman days	--	81.00	--	--
10.	**Non-farm employment**				
	i. Man days	--	45.00	37.32	29.71
	ii. women days	82.71	79.23	72.94	--
9.	Credit requirement in rupees	25750.00	25750.00	29350.00	32770.00

The E-A Frontier derived for large dry modal farm situation is presented in Fig. 3.

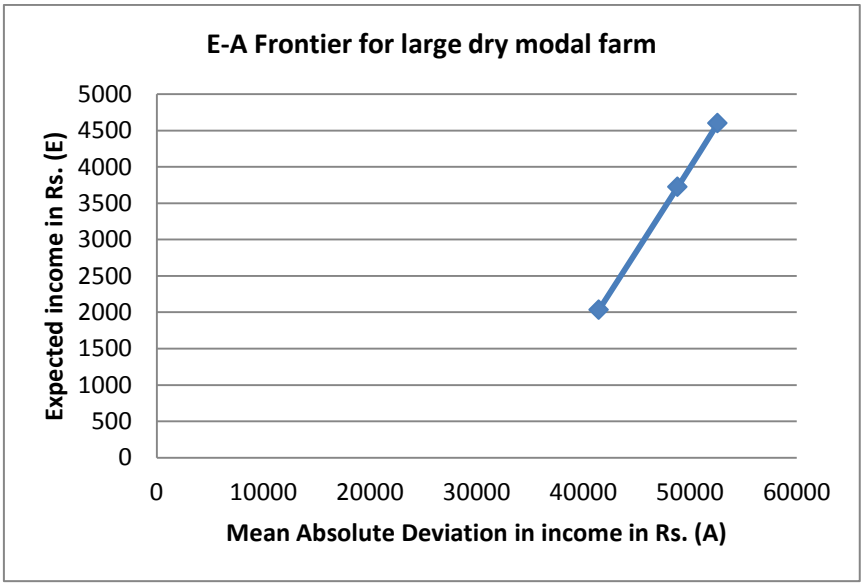

Fig. 3: E-A Frontier for Large Dry Modal Farm

The EV frontier for large farms was steeper than small and medium farms, indicating the sound risk assumption nature of large farms and expansion of credit would still improve its ability to minimize the income variability. It concurrently coincides with the theory that as the expected income increased, the absolute deviation also increased.

POLICY AND CONCLUSION

From the results of the study, it was concluded that the small dry farm was more prone to risk and it is susceptible to high risk, indicating the dire need for bridging the credit gap fully, so as to minimize the risk and to improve its income. Considering the increase in the level of expected farm income and corresponding level of mean absolute deviation in income, plan I was found superior with sufficient reduction in the variable cost. And also the inclusion of poultry and cotton would decrease the risk of income variability. As regards medium farms, inclusion of crop enterprises such as groundnut, maize, cotton and black gram and mixed crop like paddy + green gram, diary with goat, along with additional credit would decrease the income variability and with an increase in gross income. With respect to large farms, the results indicated the sound risk assumption nature of large farms and expansion of credit would still improve its ability to minimize the income variability, by incorporating more number of goats and dairy along with with crop enterprises such as maize, paddy and black gram in the existing plan. From the results of the study, provision of adequate credit to bridge the existing credit gap in small farms on the part of credit institutions is urgently needed to support dry farming and to cope up with income variability in small dry farms. The credit should also be extended to medium and large farms, which would also help them to cope up with the income variability in a better manner.

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