International Journal of Agriculture, Environment and Biotechnology
Citation: IJAEB: 8(3): 773-781 September 2015
DOI Number: 10.5958/2230-732X.2015.00085.6

AGRICULTURE ECONOMICS

An economic analysis of farm risk under water stress production environment in Namakkal district of Tamil Nadu

B. Kavitha[1*], V.Kavitha[2] and T.R.Shanmugam[3]

[1]Department of Agricultural Economics, PGP College of Agricultural Sciences, Namakkal – 637 405, Tamil Nadu, India.
[2,3]Department of Agricultural Economics, Tamil Nadu Agricultural University, Coimbatore – 641003, Tamil Nadu, India.

*Corresponding author: kavisribala@gmail.com

Paper No. 370 Received: 19 October 2014 Accepted: 24 August 2015

Abstract

Agriculture is the single largest private sector occupation and is also considered to be the riskiest business since it mostly depends on the vagaries of nature. It is important for all decision makers to know the degree of risk involved in each activity. Once the risk corresponding to an at ainable level of expected return is known, depending on the risk taking ability, different farm plans having different level of risk can be taken up by different farmer. In this context, the present study at empts to analyze the agricultural production risk in Namakkal district because of the availability of dry farms. In this study, survey was conducted in four blocks of the same district. The overall objective of the study is to analyze the farm risk to derive optimal input use and optimal cropping pat ern under the conditions of risk by an appropriate risk programming models. In the case of cost of cultivation of selected crops, total cost was high i.e. ₹ 62208 for banana and followed by tomato i.e. ₹ 38976. Banana and tomato generated higher returns viz. ₹ 97976 and ₹ 49516 when compared to maize and groundnut. The results of quadratic production function concluded that when risk level increases, optimum quantity of inputs used for the production was decreased. The results showed that even though decline trend in income, the resources which were used in the cultivation as an efficiency factor.

Highlights

- Evaluation of cropping pat ern and the causes of risk
- Quadratic production function
- Incorporation of appropriate risk management mechanism
- Farm plans to maximize the farm income

Keywords: Production, cost, factor price, inputs, marginal product, optimality.

Agriculture in India is one of the most primary sectors in the economy. As being stated by the economic data of financial year 2011-12, agriculture has acquired 17% of India's GDP and employed 60% of the country's population (Economic Survey 2013). Agriculture is the single largest private sector occupation in the country and is also considered to be the riskiest business. Risk is a phenomenon when we realize that outcome of an event is very important but unsure about the occurrence of it. Risk is inherent in agriculture since it mostly depends on the vagaries of nature (OECD 2011).

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. Agriculture is a climate dependent activity. So, it is going to be effected by climate change largely (Ahmad *et al.* 2011). Though the changes in climate is a continuous process, it has become recognizable in agricultural field from the past few years when it has started significant and lasting effect on crop production (Kondinya *et al.* 2014).

Agriculture and several other economic activities in sub-tropical to dry areas (Shinde *et al.* 2012) depend on rainfall. Rainfall in dry areas is of convective nature and usually occurs at a very high intensity for shorter duration (Sandeep *et al.* 2014). 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 the problem of endemic poverty of the farmers and the agricultural labour. 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 2010).

Agriculture today is a business proposition and no more it is regarded as a way of life. Therefore, any decision pertaining to resource organization, allocation, production planning and enterprise selection are all-important areas of farm decision making. Risk is inherent in every form of enterprise, but its intensity in input-output relation in agricultural production is comparatively high. Risk management in agriculture ranges 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. Hence it is obvious that appropriate risk adjustment mechanism should be incorporated in the management of a farm to evolve an efficient enterprise system under uncertainty thereby making production decisions more rational and scientific. This may be considered as one of the important way to improve growth prospects of the farm, hence the farm economy of the region.

This study aims at improving the efficiency of production management of farmers by evolving an optimal production plan. It also attempts to bring out the adjustment mechanism of farmers to manage the risky situations by providing suitable normative plans for different levels of risk. The analysis will indicate the level of optimal resource use that need to be reached by the farmers. Further it also indicates the optimal amount of resources as well as maximum amount of resources that can be availed and their impact on cropping pattern of the farm with risk. This study will be useful in identifying factors related to risk aversion which will help extension workers to adopt suitable approach towards such farmers.

Sharma and Paul (2007) have studied that the farmers have diversified towards vegetable crops as about 70% of gross cropped area was shared by these crops. This is also corroborated by the values of Herfindahl and Entropy indices. The study also shows that the net returns were significantly higher from vegetable crops than the cereal crops. Diversification has resulted into higher income to the farming families. There is need to support the farmers by providing them extension and marketing services. They should be encouraged to adopt better methods of production and post-harvest management of these high value crops to produce rural poverty and make the process of development inclusive.

Mishra (2008) have studied that risk management in agriculture should address yield, price, credit, income or weather related uncertainties among others. Improving agricultural extension that addresses deskilling because technological changes and also facilitates appropriate technical know-how for alternative forms of cultivation such as organic farming will be of help. Availability of affordable credit requires revitalization of the rural credit market. Organizing farmers through a federation of self-help groups with government, banks and other stakeholders playing a pro-active role would be welcome. Besides, public institutions, there is a need for a greater involvement from the civil society.

Water harvesting, intercropping, cultivating low value crops, higher concentration of fodder crops in a combination of fodder and grain crops rather than grain alone, and lower use of purchased inputs are some of the mechanisms commonly used by farmers during drought. Introduction of micro irrigation systems or agricultural water management technologies can change the dynamic of the entire farming system (Kumar 2009).

Risk exposure can be assessed by estimating the distribution function of the relevant random variables. In agriculture, the evaluation of the distribution function of crop yield has been of special interest. The evaluation can be done using econometric methods, either by specifying and estimating a parametric distribution function or by relying on more flexible nonparametric methods (Tack *et al.* 2012).

Chavas and Guanming (2015) illustrated the usefulness of quantile regression in the economic assessment of production risk in agriculture, with implications for management, technology, and welfare. The study was focused on the role of farm management and technology on risk exposure and they concluded that the quantile regression appears to be a useful tool to analyze the linkages between agricultural risk management, technology, and climate change.

The study was conducted with the objectives of measuring the risk in farming with reference to area and productivity, to derive optimal input use under different risk farming situations and to determine optimal crop pat ern under conditions of risk by an appropriate risk programming models.

Materials and Methods

Study Area

The present study at empts to analyze the agricultural production risk in Namakkal district which was purposively selected for the study because it comes under the category of dry land tract. Further the availability of exclusive dry farms was considered as an important criterion while selecting the study area. It was 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. Water was considered as the risky variable in the study area. For this present study, four blocks were selected purposively. 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 1. In each block, three villages were selected randomly and one crop was selected based on CV analysis.

Table 1. Block wise Crop Details

Sl. No.	Name of the Block	Crop	Area (Ha.)	Produc-tion (Tonnes)	Produc-tivity (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.
(Figures in parentheses denote percentage to the total cropped area of the block)

Crops which are showing high CV were selected for the study. The selected crops are Maize for Namakkal, Banana for Mohanur, Tomato for Pudhuchatram and Groundnut for Tiruchengode. CV analysis for area and production was presented in the table 2. Ten sample farmers were selected from each of the three selected villages. Thus, 30 farmers were selected from each of the sample blocks making the total sample size of 120.

Data Collection

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 pat ern, 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 asses 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. The data collected were tabulated, processed and subjected to statistical analysis.

Table 2. CV Analysis for Area and Production

S.No	Name of the Block	Crop	CV analysis for 10 years (%)	
			Area	Production
1.	Namakkal	Maize	76.55	63.49
2.	Mohanur	Banana	36.38	44.56
3.	Pudhuchatram	Tomato	54.62	49.24
4.	Tiruchengode	Groundnut	31.82	37.43

Cost of Cultivation

To estimate the costs and returns from any crop production activity, it is necessary to know about the concepts. The various concepts used are presented below for bet er understanding. Cost of cultivation included variable and fixed costs (Johl and Kapur, 2007). Fixed costs comprised of depreciation, land revenue, rental value of land and interest on fixed capital. Variable costs included the cost of human labour, bullock labour, machine labour, seeds, farmyard manure, plant protection chemicals, irrigation charges and interest on working capital.

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,

$$Y = f\,(X_1, X_2,\ldots, X_n) \qquad \ldots\ldots\ldots(1)$$

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,

$$Y = f\,(X_1 / X_2,\ldots, X_n) \qquad \ldots\ldots\ldots(2)$$

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,

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_{12} + \alpha_4 X_{22} \qquad \ldots\ldots\ldots(3)$$

In which case it is 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,

$$APP = (Y/X_1) = f\,(X_1 / X_{2\ldots,} X_n) / X_1 \qquad \ldots\ldots\ldots(4)$$

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

$$MPP = dY/dX_1 = df(X_1 \mid X_{2\ldots,} X_n)/dX_1 = f' \qquad \ldots\ldots(5)$$

MPP gives information about the additional output response to an additional input change at the margin i.e. 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, groundnut, tomato in the present study.

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_{12} + \alpha_5 X_{22} + \alpha_6 X_{32} \quad \text{.............. (6)}$$

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

$$MPPx_1 = dY/dX_1 = \alpha_1 + 2\alpha_4 X_1 \quad \text{..............(7)}$$

Equating marginal product to inverse price ratio,

$$dY/dX_1 = Px_1 / P_y$$

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

$$P_Y\,[\alpha_1 + 2\alpha_4 X_1] = P_{X1} \quad \text{..............(8)}$$

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 Palanisamy *et.al.* (2002) 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. They established the following relationship to derive the optimal input use under risk.

$$Px_1 = Py\frac{d\hat{Y}}{dX_1} - REDQ\left[P_y^2 \frac{dV(Y)}{dX_1}\right] \quad \text{.............. (9)}$$

The term V(Y) denoted variance of crop yield i.e. 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

These values (upper limits) had been applied by Shanmugam (1992) in the study of resource productivity under different risk averse farming situations to derive the optimal input use under risk

Results and Discussion

Cost and Returns of Major Crops in Namakkal District

In order to know the economics of production of selected crops in Namakkal district, the cost of production of those crops in each block were estimated. This analysis of cost would enable the farmers to examine the efficiency of allocation of farm resources and reallocate these effectively.

The results would show that the variable cost constituted major proportion of total cost with 61.25% in maize cultivation. Total cost incurred for maize cultivation was ₹ 11892.74 per hectare. Gross return which derived was ₹ 27779.58 and net return was also obtained by deducting total cost from total return about ₹ 15886.84. For banana, total fixed cost derived was ₹ 12800.99 per hectare which accounts 20.57% and total variable cost accounts 70.33 per cent. Total labour cost was the major share when compared to all other variable costs which account 30.53 per cent. Total cost of cultivation of banana was about ₹ 62208.48 and gross return obtained from banana cultivation was ₹ 97975.72. The net return was calculated by deducting total cost from gross return which was ₹ 35767.24. In groundnut cultivation, the total cost of cultivation was ₹ 24282.30, gross return was around ₹ 33265.77 and net return was ₹ 8983.47. It could however be seen that the total cost of cultivation of tomato was ₹ 38975.74 per hectare in Pudhuchatram block. In this block, average production per hectare was about 4501.47 kg from this tomato production, total return which arrived was ₹ 49516.17.

Table 3. Comparison of Cost and Returns of Four Crops (Rs/ha) in Namakkal District

Sl. No	Particulars	Maize	Banana	Groundnut	Tomato
1.	Total Fixed cost	3527	12801	3985	7647
2.	Total Variable cost	7284	43752	18089	27785
3	Managerial cost	1081	5655	2207	3543
4.	Total cost	11893	62208	24282	38976
5.	Gross return	27779	97976	33266	49516
6.	Net Return	15887	35767	8983	10540

Regarding fixed cost, it is high in the case of banana i.e. ₹ 12800.99, followed by tomato it is ₹ 7647.21. The fixed cost for maize and groundnut was approximately equal. Total variable cost was also high for banana and followed by tomato. Total cost is more for the crops banana, tomato i.e. ₹ 62208.48 and ₹ 38975.74 respectively. Cost of cultivation for maize was very low i.e. ₹ 11892.74 when compared to other three crops. Gross return derived was so high in banana i.e. ₹ 97975.72 and it was low in case of maize i.e. ₹ 27779.58.

Quadratic Production Function Analysis

Estimates of Quadratic Production Function for Maize

Based on the theoretical model of quadratic function, the empirical model of quadratic function for maize is derived and fit ed with their results. Results of quadratic production function for maize were presented in the table 4.

$$\hat{Y} = 2469.45 + 158.04\, X_1 + 28.34\, X_2 + 12.57\, X_3 - 5.12\, X_1^2 - 0.04\, X_2^2 - 0.10\, X_3^2$$

Where,

$\hat{Y}$ = Yield (Kg)

X_1 = Water use in number of irrigation

X_2 = Labour (Mandays)

X_3 = Fertilizer (Kg)

Optimal Number of Irrigation and Marginal Value Product

The table 4 showed that the optimal number of irrigation which was required for each risk aversion level. Only at particular number of irrigation, MVP is equal to MFC. As number of irrigation decreases with different risk situations, MPP increases i.e. MPP is diminishing at second region of the production function curve.

Table 4. Optimal Number of Irrigation and Marginal Value Product

Sl. No.	Risk Situations	Optimal Number of irrigation	MPP	MC = MVP
1.	Neutral Risk	11.00	45.40	360
2.	Slight Risk Aversion	9.71	58.61	360
3.	Moderate Risk diversion	4.88	108.07	360

Estimates of Quadratic Production Function for Banana

The estimated quadratic production for banana was given as:

$\hat{Y} = 17460.41 + 164.15\ X_1 + 32.85\ X_2 + 19.37\ X_3 - 1.52\ X_1^2 - 1.48\ X_2^2 - 0.005\ X_3^2$

Where,

$\hat{Y}$ = Yield (Kg)

X_1 = Water use in number of irrigation

X_2 = Labour (Mandays)

X_3 = Fertilizer (Kg)

Table 5. Optimal Number of Irrigation and Marginal Value Product

Sl. No	Risk Situation	Optimal Number of irrigation	MPP	MC = MVP
1.	Neutral Risk	33.00	63.73	240
2.	Slight Risk Aversion	30.11	72.62	240
3.	Moderate Risk Aversion	23.61	92.38	240

The table 5 showed that the number of irrigation which was required for each risk aversion level. In that particular number of irrigation only, MVP is equal to MFC. As number of irrigation decreases MPP value at each risk aversion level was increased.

Estimates of Quadratic Production Function for Groundnut

The estimated quadratic production function was given as:

$\hat{Y} = 1306.42 + 0.16\ X_1 + 7.34\ X_2 + 20.35\ X_3 - 0.008\ X_1^2 - 0.46\ X_2^2 - 0.05\ X_3^2$

Where,

$\hat{Y}$ = Yield (Kg)

X_1 = Number of rainy days during crop duration

X_2 = Labour (Mondays)

X_3 = Fertilizer (Kg)

Table 6. Optimal Number of Rainy Days and Marginal Value Products

Sl. No	Risk situations	Optimal number of Rainy days	MC = MVP
1.	Neutral Risk	10	0
2.	Slight Risk Aversion	9.20	0
3.	Moderate Risk aversion	7.43	0

It could be noted from the table 6 that each number of rainy day for each risk situation was determined as the optimal level. The optimal numbers of rainy day derived from the analysis were 10, 9.20, 7.43 for neutral, slight, moderate risk aversions respectively.

Estimates of Quadratic Production Function for Tomato

$\hat{Y} = 3418.33 + 36.81X_1 + 43.76\ X_2 + 12.32\ X_3 - 0.12\ X_1^2 - 0.39\ X_2^2 - 0.02\ X_3^2$

Where,

$\hat{Y}$ = Yield (Kg)

X_1 = Water use in number of irrigation

X_2 = Labour (Man days)

X_3 = Fertilizer (Kg)

Table 7. Optimal Number of Irrigation and Marginal Value Product

Sl. No	Risk Situation	Optimal Number of irrigation	MPP	MC = MVP
1.	Neutral Risk	17.01	32.73	360
2.	Slight aversion Risk	13.12	33.66	360
3.	Moderate Risk aversion	11.36	34.08	360

The table 7 showed that the optimal number of irrigation which was required for each risk aversion level for tomato. In that particular number of irrigation only, MVP is equal to MFC. As number of irrigation decreases, MPP decreases i.e. MPP is diminishing at second region of the production function curve.

Conclusion

Even though it was risky crop, farmers in Namakkal block were cultivating maize since it was the suitable crop to cultivate with available water in their area. It was found that the cost of cultivation was lit le higher. In Mohanur block, banana was widely cultivated by the farmers because of water availability through the presence of canal in that area. For this banana crop, cost of cultivation was very high when compared to other crops since the labour cost constituting major portion of the total variable cost. Apart from cost, gross return which was derived from banana cultivation was also high. Like banana, tomato was also high cost preferable crop. It was generating gross return of ₹ 49516.17. In case of groundnut, gross return was derived which around ₹ 33265.77 by taking unit price as ₹ 19 and net return was ₹ 8983.47. It would indicate that nearly half of the total cost was earned as net return in this groundnut production. The cost incurred for plant protection was the major cost since tomato as more sensitive to pests, diseases and other climatic fluctuations. Quadratic production function results concluded that when risk level increases, optimum number of inputs used for the production was decreased. It tends to increase in MPP value for each risk situation. Only at particular number of irrigation for each risk situation only, MVP is equal to MFC. It concluded that as number of irrigation decreases, MPP value at each risk aversion level was increased.

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. 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.

Acknowledgements

I deem it as my good fortune for having an opportunity to work under the able guidance of my beloved Chairman Dr. T.R. Shanmugam, Professor, Department of Agricultural Economics and I owe to him for his invaluable guidance, enthralling advice, constant spirit de corps, constructive criticism and ingenious inspiration throughout the course of this research endeavor and extending necessary facilities.

I am immensely thankful to Dr. K. Govindarajan, Professor (Agricultural Economics), and Dr. R. Palanisamy, Professor Department of Family Resource Management, HSC and RI, Madurai for their keen interest, stimulating ideas, helpful comments, and cooperation during the course of my investigation.

References

Ahmad, J.D., Alam and Haseen, M.S. 2011. Impact of Climate Change on Agriculture and Food Security in India. *International Journal of Agriculture Environment & Biotechnology* **4(2):** ht ps://www.academia.edu/3370536/Impact_of_Climate_Change_on_Agriculture_and_Food_Security_in_India

Anderson, J.R., Dillon, J.L. and Hardaker, B.E. 1977. Agricultural Decision Analysis. (Iowa State University Press, Ames). 78.

Binswanger, H.P. and Sillers, D.A. 1983. Risk Aversion and Credit Constraints in Farmers' Decision Making: A Reinterpretation. *Journal of Development Studies* **20(1):** 118. ht p://dx.doi.org/10.1080/00220388308421885

Chavas, J.P. and Guanming Shi, 2015. An Economic Analysis of Risk, Management and Agricultural Technology. *Journal of Agricultural and Resource Economics* **40(1):** 63–79. www.waeaonline.org/UserFiles/file/JAREJan20155Chavaspp63-79.pdf

Economic Survey 2013. ht p://indiabudget.nic.in/budget2013-2014/survey

Organization for Economic Co-operation and Development 2014. ht p://www.oecd.org/agriculture/agricultural-policies/49003833.pdf

IFMR (Institute for Financial Management and Research) 2010. ht p://ifmr.ac.in/cirm/livelihood-agri.htm

Johl, S.S. and Kapur, T.R. 2007. Fundamentals of Farm Business Management. (Ludhiana: Kalyani Publishers), 56-59, 73 and 95.

Kondinya Ayyogari, Palash Sidhya and Pandit, M.K. 2014. Impact of Climate Change on Vegetable Cultivation - A Review. *International Journal of Agriculture Environment and Biotechnology* **7**(1): 145-155. http://dx.doi.org/10.5958/j.2230-732x.7.1.020

Kumar, M. Dinesh. 2009. Water Management in India: What Works, What Doesn't, New Delhi: Gyan Books.

Palanichamy, N.V., Palanisamy, K. and Shanmugam, T.R. 2002. Economic performance of drip irrigation in coconut farmers in Coimbatore. *Agricultural Economics Research Review* (Conference Issue). 40-48.

Sandeep Kumar Tripathi, Raha, P. and Tripathi, R. 2014. Assessment of Rainwater Harvesting Capacity of Check Dam Reservoirs in Barkachha, a Part of Central Vindhyan Plateau of Mirzapur District, Uttar Pradesh, India. *International Journal of Agriculture Environment and Biotechnology* **7**(1): 121-128. http://dx.doi.org/10.5958/j.2230-732x.7.1.017

Shanmugam, T.R. 1992. Resource Productivity under Different Risk Averse Farming Situations. *Production* **33**(3): 510-513.

Sharma, T.R. and Dharam Paul, 2007. Risk Management through Crop Diversification in Hill Agriculture: Evidence from Himachal Pradesh. *Indian Journal of Agricultural Economics* **62**(3): 537. http://www.highbeam.com/doc/1P3-1381199241.html

Shinde, V., Tiwari, K.N. and Singh, M. 2012. Assessment of land and water resources of mine affected watershed in India using remote sensing and GIS. *International Journal of Agriculture, Environment and Biotechnology* **5**(4): 333-344. http://www.indianjournals.com/ijor.aspx?target=ijor:ijaeb&volume=5&issue=4&article=005.

Srijit Mishra, 2008. Risks, Farmers' Suicides and agrarian Crisis India: Is There a Way Out?. *Indian Journal of Agricultural Economics* **63**(1): 38-53. http://www.igidr.ac.in/pdf/publication/WP-2007-014.pdf

Tack, J., Harri, A. and Coble, K. 2012. More than Mean Effects: Modeling the Effect of Climate on the Higher Order Moments of Crop Yields. *American Journal of Agricultural Economics* **94**: 1037–1054. http://dx.doi.org/10.2139/ssrn.1935401