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Research Note

Rainfall Induced Production Risk in Coffee Crop and Mitigation Strategies Adopted by Farmers: An Economic Analysis[§]

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Abstract

The study analyses the rainfall induced risks in coffee production and mitigating strategies adopted by the coffee growers in Chickmagalore district, Karnataka. Results show a high variability in production of Robusta variety than of Arabica variety. The major mitigating strategy adopted against production risks by coffee farmers include sprinkler irrigation, and more use of nitrogenous fertilizers. Use of crop insurance as the risk mitigating strategy is limited to a small proportion of farmers. Yet, the reward for risk taking by coffee growers is higher than the cost of mitigation.

Key words: Rainfall induced risk, risk mitigating strategies, coffee, risk-reward

JEL Classification: G22, G 32, Q12

Introduction

India is emerging as an important international player in coffee production and trade. Coffee production in India is concentrated in the Western Ghats region of south India. The shade-grown conditions in coffee plantations in the Western Ghats region offer considerable scope for diversification with many intercrops. Coffee, largely grown as a rainfed crop, is highly sensitive to rainfall. Early blossom showers are essential for obtaining a good crop of coffee (Ahmed *et al.*, 1992). At critical stages of crop production, sufficient rain or moisture is essential, but excess rainfall is detrimental to the crop. Even longer gap between blossom and backing showers may result in production loss (Ahmed *et al.*, 1992). This has also been reinforced in Kantharaju (1989). According to Nithyashree and Siddaramaiah (1993), the yield gap in Robusta coffee is higher than in Arabica coffee and to narrow down this gap, they recommend use of fertilisers at optimal level and sprinkler system during flowering season when rainfall is inadequate. Although rainfall may affect coffee crop negatively, excess rainfall sometimes may act as a succour during times of heavy infestation of berry borer. Samuel *et al.* (2011) report that higher rainfall minimizes berry borer infestation on coffee, but higher humidity results in a greater pest infestation. Thus, weather-induced risks in coffee production are highly apparent. Fluctuation in rainfall becoming a common feature, weather-risk mitigation by way of adoption of appropriate strategies is a major management task in coffee production.

The rainfall variation being pronounced, farmers' risk-taking behaviour may take different patterns exposing them further to higher risk by way of investment on risk mitigating mechanisms. In that sense, they appear to be risk takers as the pay-off/

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§ This paper is based on the MSc (Ag) thesis entitled "An Economic Study of Risk Proneness and Mitigating Strategies Adopted by Coffee Plantation Farmers in Chikmagalore District of Karnataka" submitted by the first author under the guidance of second author, to the University of Agricultural Sciences, GKVK, Bangalore reward is usually greater for risk takers in coffee production (Anonymous, 2007). Therefore, analysis of risk mitigating strategies and their impact is crucial and an analysis would indicate the efficacy of management which should result in minimizing economic risks in coffee cultivation.

The present study analyses the risk mitigating strategies in coffee production and concomitant economic pay off. The specific issues addressed in the study are assessment of rainfall-induced risks in coffee production, analysis of the risk taking behaviour of coffee growers to minimize weather induced risks and impact of such measures on economic returns from coffee production.

Data and Methodology

Data

For present study we purposively selected Chickmagalore district where coffee is cultivated in an area of about 85500 ha with 'Arabica'as the dominant variety grown in upper hills and 'Robusta'as the major variety grown in the lower hills. The majority of coffee growers in the district are small with holdings of less than or equal to four ha. The average annual coffee production in the district is about 55000 tonnes comprising 35,000 tonnes of Arabica and 20,000 tonnes of Robusta. The average yield of coffee is 810 kg per ha for Arabica and 1110 kg per ha for Robusta, both higher than the national average.

The data were collected from both primary and secondary sources. For collecting primary data, a multi-stage sampling procedure was adopted. From the Chickmagalore district, 11 villages and from these villages, 35 small coffee growers and 35 large coffee growers were selected randomly. The classification of coffee growers was based on the criterion adopted by the Coffee Board, viz, small (< 2 ha) and large (> 2 ha). Thus, the total sample comprised of 70 coffee growers. The data pertain to the crop year 2008-09.

The secondary data on area, production and yield of coffee were collected for the period 1995-2009 from the Coffee Board. In addition, secondary data on rainfall for the past 40 years were also collected for identifying deficit, normal and excess rainfall years. Information on insurance of coffee crop was collected from the Coffee Board.

Analytical Tools

To infer about the magnitude of risk induced by variation in rainfall in coffee production, we calculate the coefficient of variation as:

$$\text{Coefficient of variation (CV)} = \frac{\text{S.D.}}{\overline{X}} * 100$$

where, $\overline{X}$ is the mean of the economic variable and S.D. is standard deviation.

The economic variables of interest are the yield and production of Robusta and Arabica varieties of coffee. The mean and standard deviations for these were computed for the 40-year period from 1970 to 2009. The CV was used to infer about the variability in yield and production of coffee during the reference period. The variability is considered as a proxy for the risk in coffee production as a result of variations in rainfall in Chickamagalore district. The reference period, 1970-2009 was divided into three periods namely, 20 deficit rainfall (100-945 mm) years (DRF), 10 normal rainfall (945-1950 mm) years (NRF) and 10 excess rainfall (>1950 mm) years (ERF).

Economics of Coffee Production

In the assessment of economics of coffee production, all costs including variable costs, fixed costs and marketing costs were considered. In addition, amortization of establishment cost of coffee and investment in risk mitigating strategies were also considered and these were treated as fixed costs. The initial capital investment on the establishment of coffee was amortized for its entire economic life using the annuity formula given below.

$$\text{Amortized cost} = \text{Initial investment} * [i/((1-(1+i)^{-n})]$$

Where, 'i' is the interest rate or opportunity cost which was considered 10 per cent, 'n'is the economic life of coffee plantation. For Robusta variety 'n' was assumed 30 years and for Arabica variety, 25 years.

Income from coffee cultivation has been worked out considering the farm gate prices of coffee prevailing at the time of data collection. The average price considered for estimating gross returns is ₹ 36/kg for Robusta and ₹ 50/kg for Arabica coffee beans. Then the total income per acre, net income over variable cost, net income, net return per kg of output and cost of production per kg are estimated following standard procedures. The net return to cost ratio (profitability index) was computed by dividing net returns by total cost.

Economics of Risk Mitigating Strategies

To minimize the negative effect of rainfall-induced risks in coffee production, the coffee growers adopt various mitigating strategies. To find their economic impact, partial budgeting approach, in terms of additional costs and additional returns, was followed. For estimating additional costs, depreciation and interest on the investment (amortized cost), operational expenditure, maintenance costs and other related expenses were considered. The details of costs incurred for each risk mitigating activity are outlined below.

(1) The sprinkler system and farm pond were the important mitigating strategies adopted by the coffee growers to supply irrigation to coffee crop in the years of deficit rainfall particularly during the months of February and March (blossom showers). Depending on coffee area, farmers had installed various sizes of sprinkler systems and farm ponds. The costs considered to work out annual cost of sprinkler system and farm ponds included.

   (a) Amortized cost of investment: The initial capital investment on sprinkler and farm pond was amortized to the economic life of the assets by assuming economic life of sprinkler system as 10 years and of farm pond, 15 years with interest rate as 10 per cent, and

   (b) Annual maintenance and other costs on sprinkler system and farm ponds.

(2) Weeding and nitrogen application was the mitigating mechanism adopted by the farmers in the event of excess rainfall particularly for the Arabica variety. Due to heavy rainfall, natural leaching of nutrients takes place in coffee lands. In addition, due to sufficient moisture, the weed growth is profuse which directly reduces the yield of crop. Costs in the form of weeding and additional supply of nitrogen were considered. These were valued at market prices prevailing during data collection period.

(3) In the year 2007, a comprehensive weather based crop insurance scheme was launched for coffee crop. Under this scheme, based on the day to day variation in rainfall, a compensation scheme has been evolved in which blossom showers, backing showers and monsoon showers are considered for payment of compensation. In the present study, a small proportion of coffee growers had bought rainfall based crop insurance.

Additional costs incurred by coffee growers under each mitigating strategy and additional returns accrued due to each of these measures were estimated to assess the economics of mitigating strategies.

Results and Discussion

Economics of Coffee Cultivation

The economics of coffee production is shown in Table 1. The total cost for Robusta coffee was ₹ 26859

Table 1. Economics of coffee cultivation in Karnataka: 2010-11

Particulars	Small farmers		Large farmers			
	Robusta		Robusta		Arabica	
	Qty	Value (₹/acre)	Qty	Value (₹/acre)	Qty	Value (₹/acre)
Total cost		26859		29311		37494
Coffee output (Quintals/acre)	9.2		9.9		10.2	
Average cost of production (₹/ quintal)		2920		2961		3676
Gross returns (₹/acre)		33120		35640		51000
Returns over variable cost (₹/acre)		19612		18947		30403
Returns over total cost (₹/acre)		6261		6329		13506
Gross returns per rupee of investment		1.23		1.22		1.36
Net returns to cost ratio		0.23		0.22		0.36

per acre among small farmers and a slightly higher (₹ 29311/acre) for large farmers. The total cost of production was higher at ₹ 37494/acre for Arabica variety, because greater management in this variety. The net income for Robusta coffee was slightly higher for large farmers (₹ 6329/acre) than the small farmers (₹ 6261/acre). But, the profitability of Arabica variety (₹ 13506/acre) was higher than Robusta variety of coffee.

Production Variability due to Rainfall Variation

The coffee growers face a myriad of production risks mainly due to weather, pests and diseases and price fluctuations. In the present study, only production risk due to rainfall variation has been considered, and measured in terms of coefficient of variation (CV) in the production and yield of coffee. Corresponding to variation in rainfall, production and productivity variability/risk has been estimated in terms of CV and details are presented in Table 2.

The average yield of Robusta coffee was lowest (633 kg/ha) during deficit rainfall years and was highest (1308 kg/ha) during normal rainfall years. In excess rainfall years, the average yield was 1227kg/ha. The average yield for Arabica variety was 745 kg/ha, 852 kg/ha and 773 kg/ha, respectively during deficit, normal and excess rainfall years. But the variability (risk) is higher in Robusta — 79 per cent during deficit rainfall and 22.92 per cent during excess rainfall years. This shows that yields in Robusta variety are likely to fluctuate to this extent, on either direction of mean level. It is mostly decreasing yield from mean level in the case of deficit rainfall, but may reduce drastically if the rainfall is in excess of requirement. For Arabica variety, estimated variability is 12.71 per cent and 16.40 per cent, respectively for deficit and excess rainfall years. In Arabica coffee, the variability in production is not so pronounced as in yield. The CV for coffee production ranges between 23 per cent and 39 per cent for Robusta and, 16 and 26 per cent for Arabica. Thus, the risk is higher in yield than in production of Robusta coffee. On the contrary, in Arabica variety, the risk (CV) is higher in production than in yield.

Risk Mitigating Strategies Adopted by Coffee Growers

To mitigate the negative effects of rainfall variation on coffee production, the coffee growers adopt several mechanisms. The most important is creation of blossom showers or supply of irrigation water through sprinklers during deficit rainfall. It was found that about 80 per cent of small and 100 per cent of large farmers had installed sprinkler systems on their farms to give blossom kind of showers during the months of February and March in the event of rainfall failure during these months. Artificial showers are also given as backing showers in the months of April and May. The second measure is the additional weeding and supply of nutrients to replenish the lost nutrients due to excess rainfall. This measure was adopted by about 91 per cent of large farmers, but none of the small farmers adopted this practice. The third measure adopted is the weather based crop insurance, which covers risks of both deficit and excess rainfall. But, only 37 per cent of large farmers purchased weather based crop insurance policy and it was mostly for Arabica variety.

Table 2. Production variability due to rainfall variation (production risk in coffee)

Particulars	Deficit rainfall		Normal rainfall		Excess rainfall	
	20 Years		10 Years		10 Years	
	Yield/ha	Production (tonnes)	Yield/ha	Production (tonnes)	Yield/ha	Production (tonnes)
Robusta Variety						
Mean value	633.31	11656	1308.37	16476	1227.17	38008
Std Dev	497.59	4575	295.30	4731	281.30	10801
Variability (CV)	78.57	39.25	22.57	28.71	22.92	28.42
Arabica variety						
Mean value	744.82	25289	852.07	32904	773.09	33052
Std Dev	94.67	6522	84.62	6393	126.76	7326
Variability (CV)	12.71	25.79	9.93	19.43	16.40	22.17

Table 3. Cost of adoption of sprinkler system in coffee plantations

Variables	Small farmers	Percentage	Large farmers	Percentage
Investment on sprinkler system (₹/farm)	16429		68819	
Annual depreciation value of pump set (₹/acre)	826	8.69	85	1.33
Annual depreciation value of sprinkler (₹/acre)	3200	33.69	2980	46.62
Interest on investment (₹/acre)	3309	34.84	2716	42.49
Annual maintenance cost (₹/acre)	824	8.70	149	2.33
Investment on farm pond (₹/farm)	64520		493960	
Annual depreciation value of farm pond (₹/acre)	1336	14.08	461	7.23
Total cost per acre	9496		6391	

Investment and Maintenance Costs of Sprinkler and Farm Pond

The investment and costs incurred on the selected risk mitigating strategies are summarised in Table 3. The initial investment on sprinkler and farm pond worked out to ₹ 16429 and ₹ 64520 per farm for small farmers, respectively. For large farmers, the initial investment was higher at ₹ 68819 and ₹ 493960 for sprinkler and farm ponds, respectively. On an average, the annual maintenance cost on sprinkler and farm ponds was higher for small farmers (₹ 9496/acre) than large farmers (₹ 6391/acre)(Table 3) due to scale economies. Among various components of annual costs, the opportunity cost of investment (interest on investment) and depreciation are the major costs in both the categories of farmers.

Cost on Weeding and N Application

This strategy was practised in the event of excess rainfall only by the large farmers. The total cost incurred on this practice worked out to ₹ 2334/acre (Table 4). The additional labour required for removal of weeds and other undesirable plants due to excess rainfall was 10.22 man days per acre and expenditure on this worked out to ₹ 797/acre. The application of additional quantities of nitrogen fertiliser by coffee growers was about 200 kilograms (4 bags of 50 kilogram each) which resulted in additional cost of ₹ 1031 as expressed by the coffee growers. Labour cost for application of fertiliser was ₹ 506/acre. Thus, the total cost on account of this strategy was ₹ 2334/acre.

Economics of Mitigating Strategies

In the present study, profitability of risk mitigating strategies in coffee production was assessed using partial budgeting approach. The additional costs and

Table 4. Costs of adoption of weeding and N application

(₹ /acre)

Variable	Cost value (₹/acre)	Percent
Nitrogen application		
Cost of nitrogen	1031	44.18
Cost on labour for fertilizer application	506	21.67
Weeding		
Cost on labourfor weeding	797	34.15
Total cost	2334	

additional returns per acre in the case of sprinkler irrigation system worked out to ₹ 9587 and ₹ 15898 for Arabica growers. The net benefit from adoption of this practice was higher (₹ 15913/acre) in Arabica variety than in Robusta variety (₹ 6311/acre). The weeding and nitrogen application during excess rainfall provided a net gain of ₹ 1520/acre (Table 5). The analysis clearly shows that the mitigating strategies not only minimize income risk but also gave reasonable returns to coffee growers. However, due to lower profitability associated with fertilisers and weeding, small farmers did not adopt this measure to counter the negative effects of excess rainfall.

Crop insurance as a mitigating strategy was adopted by only 37 per cent of large farmers. But, details of insurance premium paid according to rainfall pattern and insurance claims were not readily available with the coffee growers in the study area at the time of data collection. Hence, we were constrained in working out the economics of this strategy. But, details of costs on various forms of rainfall insurance were obtained from the website (http://www.indiacoffee.org/sites/coffeeboard.kar.nic.in/files/RISC2015_Karnataka_Booklet.pdf) of the Coffee Board and a

Table 5. Economics of mitigation strategies in coffee plantations in Karnataka

(₹/acre)

Strategies	Additional returns	Additional costs	Net benefit
	During excess rainfall year		
Weeding and N application (Arabica)	3854	2334	1520
Insurance (Robusta)	4000-7200*	91-2532**	Varies
Insurance (Arabica)	5600-9600*	42-3456**	Varies
	During deficit rainfall year		
Sprinkler (Robusta)	15898	9587	6311
Sprinkler (Arabica)	25500	9587	15913
Insurance (Robusta)	3200-4800*	91-2532**	Varies
Insurance (Arabica)	4000-6400*	42-3456**	Varies

* Based on the Agriculture Insurance Company of India Circular, 2013. The pay-out of compensation depends on variation in rainfall pattern across different periods of coffee crop.

** Premium cost per acre net of subsidy by the Government. Premium varies according to the type of farmer, location and kind of insurance for rainfall vagaries

summary of insurance premium and payout is presented in Table 5. The cost of rainfall insurance per acre varies between ₹ 91and ₹ 2532 for Robusta variety and ₹ 42 and ₹ 3456 per acre for Arabica variety of coffee.

Risk Trade-off Coefficients of Mitigating Strategies

The risk trade-off coefficients reveal the additional benefits that the coffee grower would receive by investing one additional rupee on risk mitigating strategy. These coefficients worked out for sprinkler irrigation method revealed that on average, the risk-trade-off coefficient is higher across large farmers who get an additional return of ₹ 2.48 for investment of one additional rupee on this mitigating strategy. About 60 percent of large farmers receive a reward of more than ₹ 2 for every rupee of cost on mitigating strategies. In the case of small farmers, reward from risk mitigating strategies is lower at ₹ 1.56 only. Thus, it can be inferred that rainfall risk mitigating strategies are economically viable justifying farmers' faith in them.

Conclusions

The study has revealed that the weather induced production variability is higher for Robusta coffee, than for Arabica coffee. The sprinkler irrigation is an economical means not only of reducing risk but also in providing higher profit. The crop insurance is not adopted by coffee growers, particularly by the small farmers. The study has stressed on the need for educating the small farmers regarding the advantage of the crop insurance of coffee in the event of rainfall based risks. Further, new farmer friendly insurance products may be devised to help small farmers.

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