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An economic appraisal of investment feasibility of coping strategy to combat seasonal scarcity of rainfall in Robusta coffee production in Kodagu

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Abstract

In this article the economic feasibility of investment on coping strategy (sprinkling irrigation) to combat seasonal scarcity of rainfall during the critical growth period of coffee from blossom to berry is appraised. Through partial budgeting the difference worked out is Rs. -484 indicating that, there is an additional burden of Rs. 484 per acre on the planters who hire the coping strategy. The same is the benefit due to owning the coping strategy. The gain in terms of additional yield of Robusta coffee favoured the planters who are using the coping strategy to the tune of additional 3 bags. Therefore it is found that owning the coping strategy was found to be more feasible rather than hiring. The net present value is to the tune of Rs. 25,434 per acre in the production of Robusta coffee by adopting coping strategy, while the same is negative under the situation where coping strategy was not adopted. Similarly, the discounted cost benefit ratio indicated a higher rate of benefit under the condition where coping strategy is adopted. Whereas, under the conditions of non-adoption of coping strategy, the cost benefit ratio was found to be less than one (1: 0.98 i.e., loss of Rs. 0.2). Thus, it indicates that adoption of coping strategy did have a positive effect on the production and productivity of Robusta coffee in the region. Coping strategy in Robusta coffee is being adopted by the planters not just merely because of earning higher income but to stay at the cost of production level at least (which was possible to achieve through the use of coping strategy). Further, logarithmic Cobb-Douglas production function is used to study the relationship between the total investment on coping strategy in Robusta coffee production and the relative factors. The inducement to invest on coping strategy is effectively depicted through incorporating a regression function of Cobb-Douglas type of model. It revealed a highest rate i.e., 0.64 of co-efficient of determination (R^2), which indicates that, the variables selected in the model are sufficient enough to measure the variability in Y.

Keywords: Coping strategy, sprinkler irrigation, Robusta coffee, partial budgeting, Cob-Douglas production function

Introduction

Coffee is one of the most popular and reputed beverage drinks being used by a majority of people in the world today. There is a demand for Coorg coffee besides Brazil coffee. In Karnataka, Chikmagalur, Hassan, Shimoga and Kodagu districts produce coffee. Kodagu district alone produces one third of the country's total production. The area under coffee cultivation, in Kodagu district forms 42.1 percent of the total area under coffee cultivation in Karnataka. The failure of blossom and backup showers in any year affect the entire year's production of Robusta coffee. Even heavy rains on the very next day of blossom causes extensive damage to crops ^[1]. To overcome such contingencies, planters have inevitably resorted to sprinkler irrigation as a coping strategy. Sprinkle irrigation requires pump set to pump water from the source (farm pond, bore well, rivers and streams), diesel or electricity to operate the pump set, water conveyance pipes of 3 inches and 4 inches, clamps and bends to join the pipes, lance to give the elevation and nozzle (regular jet or jumbo jet) to sprinkle water. For regular jets, one lance is fixed for 2 lengths of pipes (40 feet each), and for jumbo jets 3 lengths of pipes are used between the lances. 12 jets are used at a time per shift of sprinkling. One shift of sprinkling by regular jets (8 hours) and one shift of sprinkling by jumbo jets (4 hours) create 2.4 inches of shower for blossom. For back up shower, 4 hours of sprinkling by regular jet and 2 hours by jumbo jet is required to create 1.2 inches of required shower according to the respondents.

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In this article, the focus is to analyze the dependency of planters on the rainfall during the critical growth period of Robusta coffee which has decreased from 95.75 percent to 11.48 percent in the study area. This reflects the drastic change in rainfall pattern affecting the Robusta coffee planters, who are both the cause and victims of water scarcity. Planters, who do not have access to river water, incur more cost to store water in farm ponds and sink bore wells. Yet no one has started to use the well water for sprinkler irrigation in the study area. Planters, who do not own the water sources in the form of farm ponds and bore well, or any rivers and streams flowing nearby, buy water from the neighbour-hood.

Bore wells as the source of water for sprinkling has predominantly increased since 1995 onwards in Virajpet taluk. Planters who do not have the paddy fields near the plantation to convert them into farm ponds, where farm ponds are not retaining sufficient water and where the farm ponds have dried up over the period, have resorted to bore wells. There are instances in the study area, where the bore wells have also failed and planters had to dig deeper bore wells up to 350 feet. Apart from adopting coping strategy by owning the water sources (in the form of farm ponds and bore wells) and sprinkler sets (pump set, water conveyance pipes, sprinkler accessories like bends, jets and lance etc.,) planters in the study area hire the coping strategy. This includes both hiring the sprinkler set and buying water. At places where planters have rivers and streams flowing by the side of the plantation, hire only the sprinkler set. Whereas, the planters who do not have this facility, buy water from the neighbourhood along with hiring the sprinkler set. Some planters own only the sprinkler set and accessories but buy water as there is no paddy field to store water, or money to construct farm ponds or dig bore wells. Planters who cannot afford the initial huge sum on fixed cost often hire the coping strategy at a higher cost periodically. Out of 118 planters surveyed, it was found that only 14 of them hired the coping strategy. The importance of water for the critical growth period of Robusta coffee is evident when planters buy water if they cannot own the source of water nor have rivers and streams naturally flowing near the plantation. Despite the fact that Kodagu receives more than 2000 mm of average rainfall every year, the planters are inevitably compelled to buy water. This is due to drying up of farm ponds, streams and rivers during February and March (summer). The drying up of streams and rivers is also due to indiscriminate use of water by all the planters for sprinkler irrigation at the same time. This is the paradox of heavy rain coupled with scarcity of water. This scarcity could be attributed to lack of awareness among the people regarding rainwater harvesting. Planters who have an access to river and stream water hire only the sprinkler sets by paying Rs. 2300 per shift of 8 hours, which covers 0.75 acres with 2.4 inch of shower created. Small farmers, who have below 3 acres of total plantation also adopt coping strategy by both hiring sprinkler set and buying water by paying Rs. 2800 per shift of 8 hours from their neighbours, (only if there is water left after sprinkling by the owners). Thus, the economic dearth of water is

reflected when marginal farmers (less than 5 acres to 1 acre) also hire the sprinkler set or at times even buy only water by paying Rs. 50 to Rs. 100 per hour of sprinkling in the study area.

Except 16 percent of the area in Madikeri, the rest (84 percent) has come under the coping strategy with different intensities. Only 0.28 percent of the study area in Virajpet has not come under coping strategy, and only 3.53 percent of the total study area has not come under sprinkling. With these assured (surface water) and un-assured (groundwater) sources of water, planters are left with no choice, but to incur exorbitant cost towards storing water in farm ponds and drilling bore wells, thus leading to economic scarcity of water.

One of the hypotheses is that the degree of economic scarcity of water is reflected by the magnitude of investment on coping strategies. The time has come to expiate for the clearing of vegetation, expansion of plantation, shift to ginger cultivation etc. through inordinate investments. Further, the respondents in the study area have incurred huge sum of nonrecurring costs (fixed cost) towards coping strategy. Materializing this strategy requires liquid capital too.

Investment on construction of farm ponds on the paddy fields, bore wells, wells and deepening wells are sunken capital, incurred to have an economic access to water. Further, investment on the purchase of sprinkler sets, pump sets, conveyance pipes and accessories are subsidiary cost incurred to adopt coping strategy i.e., sprinkler irrigation. If these are the fixed costs for the structures and equipments, a huge sum of operation and maintenance cost is incurred in form of buying water, hiring sprinkler set, diesel to run the pump set, repair charges of the machines and additional human labour which is considered as variable cost of investment on coping strategy which is recurring (incurred every year). These costs include cost of domestic water too. Investment on wells and deepening wells are exclusively meant to cope with water scarcity for domestic use. The cost of sprinkler set, water conveyance pipes and accessories, construction of farm ponds, rigging bore wells, wells, and deepening wells, buying water and hiring sprinkler set, additional human labour to operate the sprinkler irrigation, diesel cost and maintenance of the machinery are worked out per acre (average) in the study area is presented in the following Table 1.

Out of 8617 acres of coffee plantation (covered in the study), 8313 acres have come under sprinkler irrigation (coping strategy). Out of which, coffee planters owning 8220 acres own the sprinkler pump set, water conveyance pipes and accessories (SACS) and rest of the planters who own 93 acres of plantation hire the sprinkler pump set, water conveyance pipes and accessories and buy water (BHCS). Hence, total area under coping strategy - total area under coping strategy by hire = Total area under SACS

For example,

8313 acres - 93 acres (BHCS) = 8220 acres of plantation is the total area under SACS which is owned by the planters in the study area.

Table 1: Investment on Coping Strategy (value in rupees)

Sl. No	Particulars	Madikeri			Virajpet			Total		
		Cost on coping mechanism	Variables*	Average value per acre	Cost on coping mechanism	Variables*	Average value per acre	Cost on coping mechanism	Variables*	Average Value per acre
	Area Under CS** (in acres)		1,487			6,826			8,313	
	No. of hrs Sprinkled		8,761			38,525			47,286	
	Fixed cost									
1	Sprinkler set, water conveyance pipes & accessories (SACS)	7,414,200	1448 acres	5,120	21,545,000	6772 acres	3,182	28,959,200	8220 acres	3,523.0
2	Farm pond (FPCS)	11,550,110	1066 acres	10,835	16,918,065	2997 acres	5,645	28,468,175	4063 acres	7,006.0
3	Bore well (BWCS)	189,992	187 acres	1,016	2,102,506	3802 acres	553	2,292,498	3989 acres	575.0
4	Wells & deepening wells (W&DWCS)	390,728	34 R***	11,492	746,244	57 R***	13,092	1,136,972	91 R***	12,495.0
	Total Fixed Cost	19,545,030	-	28,463	41,311,815	-	22,472	60,856,845	-	23,599.0
5	Variable cost/ operational cost Buying water + hiring sprinkler set (BHCS)	81,198	39 acres	2,082	142,614	54 acres	2,641	223,812	93 acres	2,407.0
6	Human labour (HLCS)	191,750	1.77 AI ^s	129	575,230	3.88 AI ^s	85	766,980	3.10 AI ^s	93.0
7	Diesel cost (DCS)	644,184	8761 HS ^u	434	2,921,656	38525 HS ^u	429	3,565,840	47286 HS ^u	429.0
8	Maintenance cost (MMCS)	236,024	1448 acres	163	562,076	6772 acres	83	798,100	8220 acres	97.2
	Total Variable Cost	1,153,156		2,808	4,201,576		3,238	5,354,732		3,026.2
	Total cost on coping strategy (FC + VC)	20,698,186		31,271	45,513,391		25,710	66,211,577		26,625.2

Note: CS** denotes coping strategy, *acres under specific coping strategy, number of respondents, acre-inch and number of hours of sprinkling are considered as variables R*** denotes number of respondents who use wells and deepened the wells to fetch water for domestic purpose only, HS^u denotes total number of hours sprinkled in the study area. AI^s denotes Acre-Inch of water sprinkled i.e. one inch of water over on acre of land. One acre-inch is equivalent to 22611 gallons or 3630 cubic feet and one cubic feet is equivalent to 28.32 liters.

Source: Tabulated from the primary data collected through the Questionnaire Schedule

$$\frac{\text{Total cost of sprinkler set + conveyance pipes + accessories (SACS)}}{\text{Total area (in acres) under SACS}} = \text{Average cost of SACS (cost per acre)}$$

For example,

Rs. 28,959,200

$\frac{28,959,200}{8,220 \text{ acres}} = \text{Rs. 3,523 is the average cost of sprinkler}$

pump set + water conveyance pipes + accessories (SACS) is Rs. 3,523 in the study area.

Average cost of farm pond (FPCS) is derived as follows,

$$\frac{\text{Total cost of farm pond (FPCS)}}{\text{Total area (in acres) irrigated by farm pond}} = \text{Average cost of farm pond FPCS}$$

For example,

Rs. 11,550,110

$\frac{11,550,110}{1066 \text{ acres}} = \text{Rs. 10,835 per acre is the average cost of farm pond (FPCS) in Madikeri}$

coffee plantation. Paddy fields are engulfed by the farm ponds. Planters who could not have farm ponds and still run short of water for sprinkling rigged borewells.

The average cost of bore well (BWCS) is calculated as follows,

What was noticed here is that the planters spent Rs. 28,468,175 on farm ponds to irrigate 4063 acres of Robusta

$$\frac{\text{Total cost of bore well (BWCS)}}{\text{Total area (in acres) irrigated by bore well}} = \text{Average cost of bore well (BWCS)}$$

For example

Rs. 189,992

$\frac{189,992}{187 \text{ acres}} = \text{Rs. 1,016 per acre is the average cost of bore well (BWCS) in Madikeri.}$

7,006 is spent on farm ponds per acre per year and only Rs. 575 on bore well. Though the cost of bore well is lesser than having a farm pond, getting water for the plantation through the bore well is more cumbersome due to reasons like, untimely installation and irregular power supply from State Electricity Board and not to mention of using diesel pump sets which are still more expensive.

Average cost of wells and deepening of wells are calculated per respondents, (since it is for the domestic purpose only).

For the planters, rigging bore wells is cheaper than constructing farm ponds. But since groundwater is dynamic, unseen, and unassured for more years, (since some of them failed to pump expected/anticipated/required quantities of water) planters opted to have farm ponds at higher cost at the cost of paddy fields. According to the calculation, Rs.

$$\frac{\text{Total cost of wells and deepening well (W and DWCS)}}{\text{Total number of respondents depending on wells and bore wells for domestic use}} = \text{Average cost of wells and deepening of wells (W and DWCS)}$$

For example

Rs. 390,728

$\frac{34 \text{ respondents}}{\text{Rs. 390,728}} = \text{Rs. 11,492}$ is the average cost of wells and deepening of wells (W and DWCS) per respondent in Madikeri.

The sum of all the average fixed costs are considered as total average fixed cost of coping strategy (nonrecurring cost)

Average cost of (X1) + (X2) + (X3) + (X4) = Total of Average Fixed Costs of Coping Strategy

Where

X₁ = Average cost of Sprinkler Accessories (SACS)

X₂ = Average cost of Farm Pond (FPCS)

X₃ = Average cost of Bore well (BWCS)

$$\frac{\text{Total cost of hiring sprinkler set and buying water (BHCS)}}{\text{Total area (in acres) irrigated by BHCS}} = \text{Average cost of hiring sprinkler set and buying water (BHCS)}$$

For example,

Rs. 81,198

$\frac{39 \text{ acres}}{\text{Rs. 81,198}} = \text{Rs. 2,082}$ per acre is the average cost of hiring sprinkler set and buying water (BHCS) in Madikeri

Though cost of owning the water source structure and machines used for coping strategies are high, owning the coping strategy is relatively less expensive than hiring the coping strategy. But, those who cannot afford to own the coping strategy hire the coping strategy at a higher cost since it is inevitable, and a question of survival. If one does not prefer to hire, he has no yield and so no income during that particular year. But, if the hiring process recurs every year, the production cost will increase. The only relief is that the huge sum of initial investment can be avoided. As far as the labour component is considered, following issues need to be taken into account. Additional human labour is employed to adopt the coping strategy (sprinkler irrigation). With every shift of 8 hours, a minimum of 2 workers are employed per shift, and not mindful of the time, sprinkler irrigation is used round the clock. Hence, 6 labourers are employed by paying Rs. 60/- per labour (per shift) for 3 shifts (24 hours). This is needed to cover the entire plantation by sprinkling before the spikes shake off.

For sprinkling, two types of jets (nozzles) are used - Regular jet and Jumbo jet. The capacity of the jumbo jet is higher than that of the regular jet. The sprinkling capacity of jumbo jet is twice the capacity (4 hours) of regular jet (8 hours). This means, to sprinkle 2.4 inch of water for around 0.75 acre, jumbo jet requires just 4 hours and the regular jet requires 8 hours of time.

One hour of sprinkling in the regular jet creates 30 cents of shower and in the same time jumbo jet creates 60 cents of shower. Therefore, use of regular jet for 8 hours and jumbo jet for 4 hours creates 240 cents of shower which is equal to 2.4 inches of shower (1 inch of shower is equal to 100

X₄ = Average cost of Wells and Deepening Wells (W and DWCS)

For example

Rs. 5,120 + Rs. 10,835 + Rs. 1,016 + Rs. 11,492 = Rs. 28,463 is the total average fixed cost of the coping strategy is Rs. 28,463 in Madikeri.

Variable cost (operation and maintenance cost) of coping strategy comprises the components like, the cost of Hiring Sprinkler set and Buying water (BHCS), cost of Human Labour to operate sprinkler irrigation (HLCS), cost of Diesel to operate the pump set to pump water (DCS) and cost of Maintenance of the Machinery (MMCS).

Average cost of hiring sprinkler set and buying water (BHCS) is calculated as follows.

cents). Total quantum of shower required for blossom shower is 240 cents (2.4 inches) and for backup, it is 120 cents (1.2 inches). The total hours of water sprinkled is converted to total inches of water sprinkled. Then the total inches of water sprinkled is converted to get the total acre-inch of rainfall created.

(One acre-inch is equivalent to 22,611 gallons or 3,630 cubic feet and one cubic feet is equivalent to 28.32 liters.) 4 1 inch = 2.54 centimetres = 25.4 millimetres = 100 cents)

If either blossom shower or backup shower fails, sprinkler irrigation is adopted accordingly to fill the gap. Planters in the study area sprinkle maximum of 12 hours by regular jet and 6 hours by jumbo jet to provide blossom (8 hours) and back up (4 hours) shower.

In calculating the average cost of human labour incurred to sprinkle one acre of plantation, the researcher has converted the total human labour cost to human labour cost incurred per acre inch of water sprinkled.

The total number of hours sprinkled is thus taken into account to quantify the water used and to calculate the cost incurred per acre-inch of water sprinkled. One hour of sprinkling by regular jet and ½ an hour by jumbo jet creates 30 cents of shower (where 100 cents is equal to 1 inch = 25.4 mm).

For the calculation of total number of hours sprinkled, number of hours of sprinkling by jumbo jet is converted to regular jet (as 4 hours of jumbo jet is equal to 8 hours of regular jet which creates the same quantity of shower).

To derive the total acre-inch of shower created, the steps followed are:

A. Total hours of water sprinkled are converted into acre-inch of water sprinkled.

First step, total hours of water sprinkled is converted to total inches of water sprinkled as

$$\frac{30 \text{ cents} \times \text{Total number of hours sprinkled}}{100 \text{ cents}} = \text{Total Inch of Water Sprinkled}$$

Where

30 = cents of shower created by one hour of sprinkling (regular jet) i.e. one hour of sprinkling = 30 cents
100 = cents for one inch of rainfall (1 inch = 100 cents)

For example,

$$\frac{30 \text{ cents} \times 8761 \text{ hours of sprinkling}}{100 \text{ cents}} = 2628.3 \text{ inch of water is sprinkled in 8761 hours in Madikeri.}$$

Second step, total inches of rainfall created is converted to total acre-inches of rainfall created as

$$\frac{\text{Total inches of water sprinkled}}{\text{Total area (in acres) sprinkled}} = \text{Total Acre-Inch of Water Sprinkled}$$

For example

$$\frac{2628.3 \text{ inches}}{1487 \text{ acres}} = 1.77 \text{ acre-inch of water is sprinkled for 1487 acres of Robusta coffee plantation in 8761 hours of sprinkling in Madikeri.}$$

Thus, by following the above 2 steps the total hours of water sprinkled is converted to total quantity of water sprinkled in acre-inch. It is summed up as follows

$$\frac{\{(30 \text{ cents} \times \text{total no. of hours sprinkled}) \div 100 \text{ cents}\}}{\text{No. of acres sprinkled}} = \text{Total Quantity of Water in Acre-Inch}$$

Where

30 = cents of shower created by one hour of sprinkling.
i.e. one hour of sprinkling = 30 cents according to the respondents.
100 = cents (used to convert total number of hours sprinkled to one inch of shower) i.e. 1 inch = 100 cents.

For example

$$\frac{(30 \text{ cents} \times 8761 \text{ hours}) \div 100 \text{ cents}}{1487 \text{ acre}} = 1.77 \text{ total acre-inch of water is sprinkled in Madikeri.}$$

B. Total human labour cost incurred (in the study area) is converted to total labour cost per acre-inch as,

$$\frac{\text{Total human labour cost}}{\text{Total acre-inch of water sprinkled}} = \text{Total Labour Cost per Acre-Inch}$$

For example

$$\frac{\text{Rs. } 191750}{1.77 \text{ acre-inch}} = \text{Rs. } 108333.33 \text{ is incurred as labour cost to sprinkle one inch of water for 1487 acres in Madikeri}$$

Hence, the labour cost incurred to sprinkle one inch of shower over one acre of plantation (one acre-inch) is calculated as,

$$\frac{\text{Total labour cost per acre-inch}}{\text{Total area in acres sprinkled}} = \text{Labour Cost per Acre-Inch}$$

For example

$$\frac{\text{Rs. } 108333.33}{1487 \text{ acres}} = \text{Rs. } 73 \text{ is the labour cost to sprinkle one acre-inch of water in Madikeri.}$$

Thus, average cost of human labour (per acre) is derived as,
Labour cost per acre-inch \times Total acre-inch of water sprinkled = Average Cost of Human Labour (HLCs)

For example

Rs. 73 \times 1.77 acre-inch = Rs. 129 is the labour cost incurred to sprinkle 1.77 acre-inch of water in Madikeri.

The average human labour cost in Virajpet to sprinkle 3.88 acre-inch of water, as per calculations, is Rs. 85. The research findings reveal that the average labour cost incurred per acre is Rs. 93 to sprinkle 3.10 inch of water in a year in the study area.

Exorbitant cost is incurred for diesel to run the pump set to draw water from the source for sprinkling. Diesel being an exhaustible resource is having a great pressure towards depletion. Its usage is worth Rs. 3,565,840 in the study area every year. According to the respondents 4 liters of diesel is consumed for an hour of sprinkling. In the study area alone, 47,286 hours of sprinkling has been done in a year. An average cost of diesel per acre is derived on the basis of number of hours of sprinkling. Therefore the number of hours of sprinkling is converted to total water sprinkled in acre-inch as discussed above. Further, average cost is derived as

$$\frac{\text{Total diesel cost}}{(\text{Total acre-inch} \times \text{Total area sprinkled})} = \text{Diesel Cost per Acre-Inch}$$

For example

Rs. 644184 / (1.77 acre - inch \times 1487 acres) = Rs. 245 is the worth of diesel used to sprinkle one acre-inch of water in Madikeri.

Diesel cost per acre-inch \times total acre-inch = Average Cost of Diesel (DCS)

For example

Rs. 245 \times 1.77 acre - inch = Rs. 434 is the average cost of diesel to sprinkle 1.77 inch of water per acre (acre-inch) in Madikeri.

Average maintenance cost of sprinkler set (MMCS) is derived for the total acreage of the respondents who own the sprinkler set and its accessories as below. (Maintenance of farm pond and bore well are not taken into consideration).

$$\frac{\text{Total maintenance cost}}{\text{Total area (in acres) under sprinkler set owned (SACS)}} = \text{Average Maintenance Cost}$$

Total area (in acres) under sprinkler set owned (SACS)

For example in Madikeri,

$$\frac{\text{Rs. } 236024}{1448 \text{ acres}} = \text{Rs. } 163 \text{ is the average maintenance cost for the owners of the sprinkler accessories (SACS) in Madikeri.}$$

In the study area, the total of the average fixed cost spent per acre is Rs. 23,599 and Rs. 3,026.2 is incurred as the total average variable cost. Thus, the total average cost on coping strategy in the study area is calculated to be Rs. 26,625.2. This is the additional cost to the production cost, without

which the average yield cannot be expected and production of Robusta coffee becomes uneconomical.

Where surface water is not available, the improved access to groundwater resources can enhance the gross irrigated area. Thus, the hypothesis - the proportion of the gross irrigated area increases with the availability of groundwater is proved. The investment on BWCS, which is the cost incurred on bore well and the area dependent on bore well for sprinkler irrigation in the study area proves that, there is physical access to ground water. Therefore, planters have invested on bore wells to irrigate their plantation. 3,989 acres out of 8,313 acres under coping strategy depended alone on groundwater with an investment of Rs. 2,292,498. Out of which 3,802 acres of plantation is irrigated by tapping groundwater in Virajpet taluk. This reflects the intensity of demand for groundwater in Virajpet compared to Madikeri.

It is evident from the table 5.5 that 96.5 percent of the total Robusta coffee plantation has come under coping strategy, which reflects the depth of seasonal water scarcity to the tune of Rs. 60,856,845 (Total fixed cost). Out of the total fixed cost, 48 percent was spent on owning the coping strategies like sprinkler set, water conveyance pipes, and accessories (SACS), 47 percent for the construction of farm ponds (FPCS) to collect water for sprinkling, and 3 percent to tap the groundwater through bore wells. Another 2 percent of the total fixed cost was spent on the wells to suffice the domestic water needs. This shows that 5 percent of the total fixed cost was spent on groundwater, which is un-assured and 47 percent of the cost on storing surface water from the streams, springs and rainfall in the farm ponds. Out of the total variable cost of rupees Rs. 5,354,732 spent on coping strategy, 4 percent of the investment which is recurring was spent on hiring the coping strategy and buying water for sprinkling, 14 percent on human labour to adopt coping strategy i.e., to fix the pipelines, the lance and jets, to fill diesel and run the pump set continuously, to attend to the leakage in the pipes connected etc. As pointed

out earlier, minimum of 2 labourers per shift of 8 hours per 0.75 acres is needed to carry out the entire process of sprinkling. The major portion of the variable cost is spent on diesel to run the motor (pump set) to pump the water for sprinkling. It works out to 67 percent of the variable cost indicating the pressure on exhaustible resource, and 15 percent of the variable cost is incurred on maintenance (MMCS) of the coping strategy, which includes repair charges, replacement of spare parts, servicing the pump set etc. This investment propositions justify the dearth of water in the study area. It is proved that there is economic scarcity of water, since the planters are incurring high cost to make good the seasonal water scarcity.

Partial Budgeting

This technique refers to estimating the outcome or returns for a part of the business, i.e., for one of the few activities. Partial budgets are commonly used to estimate the effects or outcomes of possible adjustments in the farm business before initiating such adjustments. It provides a method for deciding how far expenses and yields should be worked out without complete reworking of the whole plan. This technique is applied in the current situation to highlight the significance of coping strategy in Robusta coffee production in Table 2, where a comparison between the production with and without coping strategy is made. Based on the information, if Rs. 4,949 were to be equal to zero, i.e. coping strategy was not adopted; the yield per acre would have remained at 17 bags per acre. This otherwise indicates a decrease in the net gain of Rs. 13,351 per acre per year without adopting coping strategy. With coping strategy, the same plantation would have produced 37 bags on an average, which is equivalent to a gross return of Rs. 34,097. But without investing Rs. 4,949 on coping strategy, the plantation earns just Rs. 5,337 per acre per year (unsustainable income) and loses the chance of earning an additional income of Rs. 13,351 per acre per year.

Table 2: Partial Budgeting for Robusta Coffee Production with Adopting Coping Strategy v/s Without Adopting Coping Strategy Per Year

Debit		Credit	
a. Increase in cost per acre		a. Decrease in cost per acre	Rs.
1. Depreciation cost on sprinkler set	Rs. 1324		
2. Interest on fixed cost	Rs. 599		
3. Operation cost of coping strategy	Rs. 3026		
Total increase in cost per acre	Rs. 4949		Nil
b. Decrease in returns per acre	Rs.	b. Increase in returns per acre	
	Nil	1. Added quantity of coffee harvested per acre per year (WCS)* 37 bags - (minus) (WOCS)** 17 bags = 20 bags	Rs. 18300
		2. Therefore additional income generated 20 bags X Rs. 915	
A. Total increased cost and reduced returns (total of a & b)	Rs. 4949	B. Total reduced costs and increased returns (total of a & b)	Rs. 18300
Net change in income due to adopting coping strategy (gain) is B – A ∴ 18300 - 4949 = Rs. 13,351 per acre per year			

Note: *WCS denotes With Coping Strategy **WOCS denotes Without Coping Strategy

Source: Tabulated from the primary data collected

Thus, the sustainability of the economy of Kodagu (which is dependent on coffee plantation) is directly dependent on the sustainability of water resources. Therefore, planters in Kodagu have to realize the fact that, water during the critical growth period of Robusta coffee is not free, and hence they

are forced to hire the coping strategy at higher cost. This is analyzed with the help of partial budgeting technique by comparing the feasibility of owning a coping strategy (investment on sprinkler set and investment on different water sources) and hiring the coping strategy with water in

Table 3. In this analysis, the net additional cost (loss) is worked out against the cost of investment on the assets and the investment on the infrastructure minus the hiring charges for the coping strategy. It worked out to Rs. -484 indicating that, there is an additional burden of Rs. 484 per acre on the planters who hire the coping strategy. The same is the benefit due to owning the coping strategy. The gain in terms of additional yield of Robusta coffee favoured the planters who are using the coping strategy to the tune of additional 3 bags. During the critical growth period of coffee, the planters who own the coping strategy could sprinkle without delay. This earned an additional income of Rs. 3,229. For those who hired the coping strategy could not irrigate on

time during the critical growth period, because of reasons like shortage of water and non-availability of sprinkler sets on time. There is a decline of 3 bags in the yield under the hired coping strategy and due to shortage of water for sprinkling the required hours. This is because, the planters who hire the coping strategy had to wait for their neighbours to complete their sprinkling before they lend it to others and by then water in the source would have reduced. Therefore owning the coping strategy was found to be more feasible rather than hiring. Hence, in the study area, in spite of higher initial investment cost on coping strategy, the planters preferred to have their own source of water and sprinkler set.

Table 3: Partial Budgeting for Owning the Coping Strategy v/s Hiring the Coping Strategy - A Comparison

Debit		Credit	
a. Increase in cost per acre		a. Decrease in cost per acre	
(i) a. Depreciation on coping strategy per year + b. Interest on fixed cost per year is equal to Minus	Rs. 1324 Rs. 599 Rs. 1923	Nil	
(ii) a. Hiring cost for sprinkler irrigation accessories and pump set with water per year	Rs. 2407		
Total increase in cost per acre	Rs. -484		
b. Decrease in returns per acre		b. Increase in returns per acre	
Nil		1. Added quantity of coffee harvested per acre per year under owned coping strategy was 34 bags - 31 bags = 3 bags (under hiring coping strategy) 2. Therefore additional income generated 3 bags X Rs. 915	Rs. 2745
A. Total increased cost and Rs. reduced returns (total of a & b)	Rs. -484	B. Total reduced costs and increased returns (total of a & b)	Rs. 2745
Net change in income (gain) due to owning the coping strategy is B - A ∴ 2745 - (-484) = Rs. 3,229			

Source: Tabulated from primary data collected through the Questionnaire Schedule

In addition, the encouragements from the institutional financing through the local banks are significant. Therefore, the planters are motivated to adopt the coping strategy under owned condition. On the other hand the planters, whoever hired the coping strategy had to resort for this method only under the condition of necessity than on the regular basis as discussed before.

Though the planters who adopted coping strategy by hiring at higher cost than owning, and incurred a loss of yield to the tune of 3 bags as calculated in the study area, it is considered far better than not adopting the coping strategy. If this precious water resource is not managed properly (sustainable water resource management) the economy of Kodagu cannot be sustained. Despite innumerable advantages, the planters encounter some constraints during the adoption and operation of sprinkler irrigation system as a coping strategy. High initial investment, maintenance of water balance in the ponds and bore wells, (inadequacy of water supply) high cost of diesel, 24 hours of continuous work during the time of sprinkling, procedure of the bank for availing loans, etc., were found to be the major constraints faced by most of the planters.

Further, logarithmic Cobb-Douglas production function is used to study the relationship between the total investment on coping strategy in Robusta coffee production and the relative factors as shown in table 4. The inducement to

invest on coping strategy is effectively depicted through incorporating a regression function of Cobb-Douglas type of model.

The inducement to invest (Y) is assumed to be the function of X_1, X_2, \dots, X_6 . Hence, the curvy linear (logarithmic) Cobb-Douglas production function is,

$$Y = \alpha \sum_{i=1}^6 x_i^{\beta_i} e_i$$

Where,

Y = Total investment on coping strategy per acre (dependent variable)

α = Constant

β = Regression co-efficient

$x_i = X_1 \dots X_6$ (independent variables)

x_1 = Total holding size inclusive of paddy fields (in acres)

x_2 = Area under Robusta coffee (in acres)

x_3 = Operation cost of coping strategy per acre (in Rs.)

x_4 = Total water demanded per acre (in acre inch)

x_5 = Yield of Robusta coffee per acre (number of bags, where 1 bag = 50 kgs)

x_6 = Dummy variable (0 = without coping strategy, 1 = with coping strategy)

e = error term

R^2 = Co-efficient of multiple determination

The function fitted is tested using the adjusted co-efficient of multiple determinations (R^2) which is given by:

$$R^2 = \frac{(1 - R^2)(n-1)}{(n-p)}$$

Regression sum of squares

$$R^2 = \frac{\text{Regression sum of squares}}{\text{Total sum of squares}}$$

Where,

n = Number of observations

p = Number of regression co-efficient estimated or number of parameters

Table 4: Cobb-Douglas Production Function for the Estimation of Factors Influencing Investment on Coping Strategy (n = 118)

	Factors (independent variables)	β -Co-efficient	t-value	Significance (p)
X ₁	Total holding size (in acres)	-1.78	-0.66	NS
X ₂	Coffee area (in acres)	1.56	0.60	NS
X ₃	Operational cost of coping strategy per acre (in Rs.)	-0.40	-0.41	NS
X ₄	Quantity of water used (in acre-inch)	0.27	0.29	NS
X ₅	Yield per acre of Robusta Coffee (in kgs.)	12.35	3.07	(0.01) 1%
X ₆	Dummy variable	9.83	11.80	(0.01) 1%
α	Constant	-23.64	-	-
R^2	Co-efficient of multiple determination	0.64	-	-

Note: n denotes number of observations, NS denotes that the variables are not significant to bring in changes in Y

Source: Tabulated from the primary data collected through the Questionnaire Schedule

The regression analysis is carried out using the logarithmic Cobb-Douglas type of production function with the help of Lotus 1, 2, 3. It revealed a highest rate i.e., 0.64 of co-efficient of determination (R^2), which indicates that, the variables selected in the model are sufficient enough to measure the variability in Y. It means that the estimated regression line is able to explain 64 percent of the total variation of dependent variable values around mean, and remaining 36 percent of the total variation in Y is not accounted by regression line which can be attributed to the factors included in the error term (e). The dependent variable Y i.e., the investment on coping strategy per acre is influenced by the variables such as adoption of coping strategy (dummy variable) and the yield per acre of Robusta coffee. These two variables are found to be significant at 1 percent level. The variables thus indicate that the investment cost of coping strategy is directly related to the yield parameter of coffee rather than the other factors. The significance test paved way to highlight the importance of adoption of coping strategy through the investment made to produce sustainable yield in Robusta coffee. The dummy variables reflect the importance on the investment on coping strategy because without investing on it, the production of Robusta coffee is unsustainable. Hence, in order to be at a level, where the income from coffee exceeds the total production cost, the coping strategy is mandatory in almost all the coffee estates. Thus, the production function reveals the significance of taking up coping strategy (investing on water) in Robusta coffee plantation. Hence, from the above analysis, it can be inferred that the additional expenditure borne on investment on coping strategy does influence hike in the productivity of the coffee plantation, thereby increasing the gross income, which subside the total cost of production.

Further, cash flow analysis is adopted to evaluate the economic viability of undertaking (investing on) coping strategy in Robusta coffee plantations, particularly during February and March, which is considered to be the critical growth period of Robusta coffee.

Conclusion

As of now, expanding plantation is a big question for, even

the groundwater table is decreasing. Hence, the hypothesis, water scarcity is directly proportional to the size of the holding is proved. As the gross area under irrigation increases, economic water scarcity increases with further increase in the investment. The economic feasibility of the additional cost for coping strategy is another topic altogether. The issues discussed so far clearly indicate the problems related to water and its scarcity. This, however, is not a new phenomenon. The importance of water, need to collect, preserve and protect the rain water, and measures towards rain water harvesting have been taken up since time immemorial. There is sufficient evidence to this.

Meeting future demand for coffee under climate change is a challenge. Approaches that can inform where coffee may grow best under current and future climate scenarios are needed. Robusta coffee (*Coffea canephora* P.) is planted in many tropical areas and makes up around 40% of the world's coffee supply. However, as the climate shifts, current Robusta areas may become less productive, while in other areas new growing regions for Robusta may emerge. As the climate continues to warm and shift in coming decades, maintaining and increasing the global coffee supply faces two key challenges. First, areas suitable to grow Arabica coffee portably, currently supplying around 60% of the world's coffee, are projected to decrease under climate change (Moat *et al.* 2017) [3]. Coffee quality and growing areas are likely to decline due to increasing temperatures (Bunn *et al.* 2015a) [4]. East Africa is projected to experience large reductions of suitable climate areas in its main Arabica producing regions (Moat *et al.* 2017) [3]. There is, therefore, an urgent need for research to identify ways in which the global coffee industry can maintain and / or increase supply in the face of these two compounding issues. Even so, while Robusta has the potential to complement Arabica's consumer markets or creates new ones, its expansion, and thus its ability to offset falling global coffee supply, could be compromised if new growing areas are inaccurately assessed. As such, research is needed to map where Robusta could be grown under climate change. Current zoning approaches, which are largely based on species distribution modelling (SDM), rely on a binary assessment of suitability (i.e., if the crop is present the

location is deemed 'suitable' if absent then 'unsuitable'). Suitability models, while helping to advance our understanding of the risks that climate change pose to future coffee production (Bunn et.al. 2015b) ^[5] could be complemented by other approaches to give a more detailed and refined picture of which areas may be the most promising for future coffee production. The integration of suitability models with productivity models (i.e., models which estimate coffee yield (i.e., yld/ha) as well as pest risk assessments, along with spatial evaluations of critical socio-economic and environmental factors is one way a more detailed and holistic view of future potential coffee growing areas could be achieved. However, methods and examples on the integration of these various modelling approaches to provide a holistic assessment of where the best future areas may be to grow coffee are absent from the scientific literature. Besides, coffee product has become a strategic commodity for the community to be developed towards the agricultural industry. One of the effects is economic growth where coffee is able to improve a series of processing processes from upstream to downstream in coffee products simultaneously and affect other stages of product flow thereby increasing community's income. The coffee roasting system is an essential phase to realize the characteristic taste and smell of coffee beans. Hence, coffee roasting is a complex heat transfer process. Reactions that occur during the roasting process such as pyrolysis, oxidation, caramelization and maillard can affect the coffee beans turn brown to blackish and the coffee tastes different according to the treatment. Roasting is a method used in coffee bean material using a certain heat source to increasing the colour of the coffee as expected so that a distinctive smell and taste is obtained from the coffee beans. There are three scale levels in the roasting process, namely the lowest level of roast maturity (light roast) with a roasting temperature of around 193-199 °C, a medium roast level of maturity (medium roast) with a roasting temperature of around 204 °C, and the highest level of roast maturity (dark roast) with roasting temperature 205-220 °C. The length of the coffee bean roasting time, the weight will decrease due to the reduced water content. One of the important scales in paying attention to the quality of a product is colour. Good taste and aroma can be seen from the change in colour of the coffee beans when roasted⁷. Coffee beans material during the roasting process varies from 1 to 5% which is influenced by product ingredients, high temperature, and time of roasting, as well as cooling treatment ^[8]. Closed roasting has the benefit of forming a special aroma and changing the taste of coffee beans. This is because coffee beans are not affected by external odours, especially burning fuel or gas ^[9]. For better quality coffee beans, improvements and development of coffee bean roasters are carried out starting from a simple method of using manual roasting to using an automatic roaster that can be controlled by heat in the roasting tube and the length of time for drying coffee beans. The roasting process of coffee beans is influenced by temperature, time, the machine used and the type of fuel or heat source. A coffee roaster with a gas heat source takes 20 to 30 minutes to roast. While the rotary cylinder type roaster with a gas heat source takes 1 hour for 12.3 kg of coffee beans. The use of a roaster with a gas-based heat source is technically cost-effective, in addition, there is also a roaster using electric power. Coffee roasting research using an electric heat power is able to produce coffee beans with dark

roast quality at a temperature of 205 °C with a roasting time of 90 minutes. Another study using a cylindrical tube type roaster takes 40 to 50 minutes to raise the temperature to 205 °C. The objective of that study was to the differences of characteristics of Arabica and Robusta coffee roasting using a Rotary Cylindrical Tube Roaster with a heat source, namely electricity. With all these techniques and procedures, by the time coffee is had as a beverage, the energy used is immense which can be further measured in mega joules.

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